THE

BRITISH GUNNER,

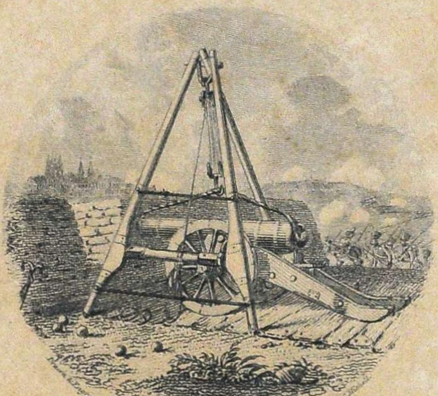
&c. &c.

THE BRITISH GUNNER

BY

Captain J. Morton Spearman,
H. P. Unattached.

Second Edition.



"En retranchant le superflu, on apprend mieux le nécessaire."

Montécuculi.

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1828.

TO FIELD MARSHAL

THE DUKE OF WELLINGTON,

IN WHOSE SPLENDID ACHIEVEMENTS

THE ROYAL ARTILLERY

HAVE FOUND

THEIR BEST SCHOOL OF PRACTICAL SCIENCE;

THIS LITTLE VOLUME

IS RESPECTFULLY INSCRIBED,

BY

HIS GRACE'S

OBLIGED AND OBEDIENT HUMBLE SERVANT,

THE AUTHOR.

PREFACE.

A Pocket Manual of Artillery having already been, for many years, in very general use in the Ordnance Service, it will perhaps be expected that I should shortly explain why I have ventured to publish another little work on the same subject.

It would be absurd to claim an hereditary title in the 'Pocket Gunner;' but I may be permitted to feel an hereditary interest in a subject which engaged my father's professional attention, and was principally illustrated by his labours. The 'Little Bombardier and Pocket Gunner'

was first published in 1801, and was compiled by the late Major Ralph Willett Adye. I have in my possession my father's papers, from which a very material part of that work was composed; the passages extracted being marked in his hand-writing, for that purpose.

In 1802, a second edition of the 'Bombardier and Pocket Gunner,' revised and corrected, was published, with the name of the compiler on the title-page. The memoranda for this improved edition were also, to a great extent, furnished by my father; who, however, declined any mention of his name, or share in the work. It afterwards went through four impressions, without material alteration. Major Adye died in 1804, and my father, in 1808.

In 1813, Major Eliot prepared a seventh edition, in which, however, he only partially inserted some of the details of the improved practice which experience had suggested; and in 1827 he published an eighth edition;—but in this also, while much obsolete matter was

retained, many of the improvements, to which the advanced state of the service had led, were entirely omitted.

It was suggested to me, by many of my military friends, that I should undertake to compile an improved work. I was satisfied, from my own observation, that this might be done, and I have therefore attempted it. I am quite sensible that much yet remains to make this work complete; but I trust that my little volume is not altogether unworthy of approbation, as an attempt to afford to the profession information on many points of importance, which have been altogether omitted in the former work.

I have thought it very desirable that a work of this kind should contain not only the practice of Artillery and Engineering, as was the case with the 'Bombardier and Pocket Gunner,' but also some elucidation of the theory of those sciences; and I have therefore introduced several scientific papers on these subjects. Besides, undertak-

ing to correct the errors of obsolete rules, and to enlarge and extend the quantity of useful information with which such a book should assist the practice of the professed artillerist, I have farther endeavoured to make the present volume of some worth, on other points, to individuals in the lower ranks of the Artillery, as well as to the junior members of the service in general.

An acquaintance with the first principles of fortification,—as well permanent as field,—is indispensable to every officer; because there are none who may not be called on, in the exigencies of the service, to direct or assist in the construction of field-works, temporary bridges, gabions, fascines, &c. It is therefore presumed, that a few practical rules, applicable to these various departments of professional science and mechanical labour, may not be found unacceptable or useless. It is acknowledged that this sort of information has not yet been satisfactorily given in a portable compass; and I venture to

hope, that it will be found that I have not been altogether unsuccessful in an endeavour to supply it.

In compiling the "*British Gunner*," I have received great assistance from many of my military friends; but I am, in an especial manner, bound to acknowledge my obligations to Lieut.-General Cuppage, to Major-General Millar, and to Colonel Sir A. Dickson, for the facilities which they afforded me, in permitting me to have access to the information contained in the several departments over which they respectively preside, with so much advantage to the public service. To Sir Alexander Dickson, in particular, I have to return my thanks for the support which I experienced from him, when very serious obstacles would otherwise have been thrown in my way; and to which support I was indeed indebted for the Master-General's permission to procure information, which had previously been refused to me, from the Royal Laboratory. I am bound, also, to offer my

best thanks to Colonel Sir Augustus Frazer, to Colonel Drummond, and Lieut.-Colonel Lloyd, and to Captains Scott and Barlow, for the several valuable papers which they freely allowed me to consult,—and to Major Charles C. Michell, for his kindness in designing the diagrams in the body of the work, and the vignette on the title-page, the latter of which he engraved.

Woolwich Common,
April 23, 1828.

NOTES

EXPLANATORY OF THE SEVERAL SUBJECTS TO WHICH THEY RELATE.

SHRAPNEL-SHELLS.—I have been restricted from saying any thing on the subject of these shells, or spherical case-shot, as, to the prejudice of their ingenious inventor, Major-General Shrapnel, this species of ammunition is now most unaccountably termed. This prohibition has arisen from a very proper desire to retain in our own hands the secret of this destructive missile. Of the utter ignorance of its principles of construction, in which the military of other nations have as yet been held by this salutary precaution, a ludicrous example will be recognized, by the initiated of our own service, in the following extracts from a new work on artillery, by Captain Decker, of the Prussian army:—

"Les *Schrapenschels* sont des projectiles qui portent le nom de leur inventeur, un colonel Anglois. Ce sont simplement des obus dans lesquels sont renfermées des balles de fusil, qui projettées au loin par l'explosion, devaient, suivant l'inventeur, produire un effet très-meurtrier. Les Anglois pretendent devoir le gain de la bataille de Talavera à l'usage qu'ils y firent de cette espèce d'obus."

This, it will be allowed, is a very *simple* definition, and we may let it pass. But what will British officers say to the following note, appended to the above extract by the translators of Captain Decker's work ?—

"Cette assertion est loin d'être exacte, et ces projectiles ne peuvent pas être, à beaucoup près, aussi terribles qu'on les représente. Les balles n'étant point serrées sur la petite quantité de poudre renfermée dans l'obus, celle-ci ne peut leur communiquer, par suite de l'explosion, une quantité de mouvement capable de les porter assez loin et avec assez de force pour les rendre vraiment meurtrières. Des expériences faites à Vincennes sont venues à l'appui de ce raisonnement, et ont démontré que les *Schrapenschels* étaient réellement de fort peu d'effet. Pour les rendre plus meurtriers, un officier Français a proposé de les composer de deux enveloppes concentriques en fer coulé, entre lesquelles seraient placées les balles, et dont celle de l'intérieur contiendrait la poudre. Il n'est pas douteux que de cette manière la force de l'explosion ne communiquât aux balles une quantité de mouvement beaucoup plus considérable, et ne les rendît par conséquent beaucoup plus meurtrières ; mais aussi la fabrication en deviendrait certainement beaucoup plus difficile et plus coûteuse.

"Non contens de donner tousleurs soins à cet ouvrage, les deux collaborateurs se sont éclairés des conseils d'officiers d'artillerie distingués, et, entre autres, de ceux de M. le lieutenant-général comte Gassendi, qu'il suffit de nommer, et de M. le colonel Marion, inspecteur des fonderies, dont les connaissances étendues et la longue expérience sont généralement connues."

This is bad enough, considering it to have come from

French officers of any rank, or at any time; but that it should proceed in this day from officers of such pretension as Colonel J. Ravichio de Peretsdorf, "Chevalier des ordres royaux de Saint-Louis et de la Légion d'honneur, Archiviste des bureaux de l'artillerie et du génie au ministère de la guerre, etc.;" who, moreover, boasts "d'avoir servi d'abord en Piémont, puis en Autriche, et enfin en France, et ayant, dans sa longue carrière militaire, occupé tous les grades depuis celui d'élève d'artillerie, et rempli presque tous les emplois, soit en paix, soit en guerre, soit dans le personnel, soit dans le matériel;" and from Captain A. P. F. Nancy, who, in addition to being a member of the above orders, writes himself an "*ancien élève de l'école polytechnique*, de la société des lettres, sciences, et arts, de Metz, etc.," is really too ridiculous. The very cadets who have been only twelve months in our much-decried Royal Military Academy, would be ashamed of betraying so much ignorance; and yet there are to be found those persons who can publish to British Artillerists that, if they aspire to proficiency in their profession, they must devote days and nights to the study of French authors!!

Tables of Ranges.—The following memorandum will account for the omission of the usual tables of ranges in this work:—

"In the spring of the year 1826, a course of practice was commenced with a view of forming correct tables of ranges, elevations, &c. for every nature of gun, mortar, howitzer, and carronade in the service. It was discontinued for a short time, during which it was remarked, that the charges for the mortars at practice were much larger than had been formerly

required for the same ranges. An inquiry into the cause of this circumstance was instituted; and experiments were, in consequence, made in 1826 and 1827, with powder manufactured at different periods:—the result of which proved, that the powder of recent manufacture was inferior in strength to that of older date.

"The practice for the formation of the tables was of course not resumed until the subject had been fully investigated, which has now been done; and it is, in consequence, proposed to renew the practice, rejecting all that has been already finished, the powder having been brought back to its former strength."

It is a fortunate circumstance that this discovery was made during a period of profound peace: what might the consequences not have been, had one of our ships, provided with this inferior powder, met an enemy's vessel? The tendency, moreover, of this deterioration in the manufacture was to revolutionize the whole system of artillery as at present established.

Tangent Scales.—Under this head I have pointed out what appears to me to be a radical error in the graduation of these scales; and I have, at the same time, ventured an opinion that the reasons advanced in favour of the false graduation are far from satisfactory. I shall here add a suggestion, which I some time ago made to the Director of the Proof Department, which would, I think, not only remedy the inconvenience complained of, and, at the same time, obviate the necessity of having tables of ranges, in a book like the present, but also ensure greater accuracy and rapidity of fire.

My suggestion was to the effect that the ranges of the guns, howitzers, and carronades should, when completed, be marked upon their tangent-scales and quarter-sights, either opposite the relative degrees of elevation, or in lieu of them; and that those of the mortars, together with the relative lengths of the fuze, &c. should be painted or engraved on the rear transoms of their beds. If this plan should, as I have reason to believe it will, be adopted, it will be a very considerable improvement upon the present method. I should myself prefer seeing it combined with a correction of the old method by tangents.

Construction of Iron Guns.—I had long been of opinion that, in the casting of iron ordnance, much more metal was consumed than was at all necessary; and it had occurred to me, that, by a series of experiments, we might arrive at the knowledge of a law by which guns might hereafter be cast upon better and more scientific principles; and I made a communication to that effect to the Master-General, who referred it to the Select Committee at Woolwich, to report upon. It was not thought proper at the time to entertain my suggestion; but I have since had the satisfaction of seeing that some guns have been constructed with much less thickness of metal; and I am quite certain that it will eventually be admitted that we have hitherto proceeded upon a very bad system in that respect.

Elevating Screws.—A change in the construction of these screws has taken place of late years, by disengaging them from the cascables of the guns, &c. I am afraid this alteration will not prove advantageous in the degree antici-

pated. However, the following are a few of the disadvantages attending it :—

In travelling, from the repeated jolting of the carriage, the screw is liable to be injured, and the whole weight of the gun is left free to act, like a sledge-hammer, upon the screw after every discharge. It may also be added, that the power of limbering up and unlimbering—by no means an unimportant consideration—is diminished at least one-half.

HOWITZERS.—Under this head will be found the new howitzers of General Millar ; and they are certainly, in some respects, superior to the old. The old, from the shortness of their bore, were very inaccurate in their fire :—the new are, to a certain extent, improved in this respect ; but then, in loading them, the man who puts home the shell makes use of a clumsy instrument like a pair of pincers, which he applies to the fuze at the risk of disturbing it, and thereby exploding the shell in the bore. It appears to me that these howitzers would be improved by lengthening the bore at least a calibre ; and by discarding the pincers, and applying grummets or wood bottoms to the shells in lieu of them.

EXERCISE.—I have omitted, under this head, to give the manœuvres of horse artillery, because they cannot be readily understood without the assistance of figures ; and this would render the book too expensive for general circulation. I have, in like manner, omitted the field battery manœuvres—as the regulations for their movements, laid down by my father, are at present undergoing a revision ; and I am anxious to see the new code before I do any thing in the business.

THE

BRITISH GUNNER.

AMMUNITION.

For *Artillery*. See the words ARTILLERY, CHARGE, and CARTRIDGE.

Small arm ammunition is now generally packed in rectangular boxes. An ammunition waggon of the new pattern will carry *twenty* of these *boxes*, viz.—*eight* in the *limber*, and *twelve* in the *body* of the waggon. For the number of cartridges, &c. of each nature packed in a box, see the word CARTRIDGE.

AMMUZETTE.

A small species of ordnance, invented by Marshal Saxe. See the word GUNS.

AMPLITUDE,

In the science of gunnery, signifies the range of a projectile, or the right line upon the ground subtending the curvilinear path in which it moves.

ANTIMONY.

A metallic substance, of a silvery white appearance; and, in its ordinary texture, brittle and crystalline. It is very rarely found in a pure state in nature; as an ingredient in the composition of fire-works, it produces in the flame a whitish appearance, and adds activity to the fire, rendering it at the same time clear, lively, and difficult to be extinguished.

APPROACHES.

A term used to designate the direct advances of the trenches, or zig-zags, in the attack of a fortified place. See the words Sap and Trenches.

ARCHES (Equilibrium of).

An arch is an arrangement of materials in a curvilinear form, for the purpose of supporting an incumbent weight; therefore, when several beams, situated in a vertical plane, are connected together at any angles with each other, and rest, at the two extremities of the system, on immoveable points, the weights, which, if applied at the angular points, will keep the whole in equilibrio may be determined in the following manner.

A vertical line, passing through any one angular point, is assumed of any length, to express a weight applied at that point; this is resolved into two forces in the directions of the adjacent beams, and these forces express the pressures which that weight exerts

in those directions. These must be counteracted by equal pressures, in opposite directions, arising from weights at the two next angular points; therefore, by resolving each of those opposite pressures into two forces, one, in the direction of a vertical line passing through the angular point at which it acts, and the other, in the direction of the next succeeding beam; the vertical force will express the weight to be applied at that angular point to keep the former beam in equilibrio. Similar operations are supposed to be repeated at all the angular points, and if weights, equal to the several vertical forces, be applied at those points, either suspending them below, or raising columns of materials vertically above them, to certain heights which are proportional to the weight, the system will be in equilibrio.

The values of these vertical lines may be computed, trigonometrically, for any beams, even when they are indefinitely short, and when the polygon they form may be considered as a curve. In this latter case the vertical lines will be found to be inversely proportional to the radius of curvature and the square of the sine of the angle which the vertical line, at any point, makes with a tangent to the curve at that point. But because the materials incumbent on an arch are equally diffused over it, the above formula requires a modification on account of the variable breadths of the parallelograms of material standing vertically over the

indefinitely small and equal portions of the curve or intrados of the arch, and becomes $H \propto \frac{1}{\text{Rad. Sin}^3. \text{ I}}$; where H = the height of the column of material at any point, and I = the inclination of the vertical line to the tangent at that point. Therefore, the height of the column, at any one point, being assumed, the height over any other point may be found.

The figure of the extrados, given by the formula, is not always such as to permit a road over the arch to coincide with it, being sometimes too low over the hances, and infinitely high over the foot of the arch. But the infinite height may be dispensed with, on account of the union of the masonry of the arch, with that of the piers; and the want of height at the hances may be remedied by carrying the road-way upon secondary arches over those parts, so as to leave vacuities, and thus take off the excess of pressure which would arise from filling them up to the required height.

The curve given to the intrados of the arch, if inverted, being the same as that which would be assumed by a flexible line, or chain, suspended between two fixed points, and loaded with weights proportional to those determined by the formula; this theory of equilibration has been called the catenarian. It was first developed by Mr. Emerson and Dr. Hutton.

But some engineers object to this theory, that it is

founded on principles very different from those which take place in the actual circumstances of an arch; and they prefer the following which was invented by Mr. Atwood.

The arch being considered as an assemblage of voussoirs, or stones in the form of frustums of wedges, and tending towards the centre by their weight, the force by which any one voussoir is impelled upwards, in consequence of the pressure of the adjacent voussoir below, must be counteracted by an equal tendency downwards, arising from the weight of the voussoir itself. And from the theory of forces, the proportion of the weights, and consequently of the lengths of the voussoirs, may be determined.

When the arch is in a state of equilibrium, the weight of each voussoir will be found to be proportional to the difference of the tangents of the two angles formed by the intersections of vertical lines, and lines which are tangents to the intrados of the arch at the lower extremities of the joints of the same voussoir. Therefore, the weight of any one voussoir being given, the weights of all the others may be found; or, since the lengths are proportional to the weights, when the breadths are equal, the lengths of all the voussoirs may be obtained in the same manner.

ARCHITRAVE.

The master-beam, or chief supporter, in any part of a subterraneous fortification.

ARMS.

Weight, Dimensions, &c. of SMALL ARMS.

NATURE OF ARM.	Calibre.	Length of Barrel.	Length of Stock.	Length of Bayon.	Length of Total.	Weight.
	In.	Ft. In	Ft. In	In.	Ft. In	lbs. oz.
Musquet............	·76	3 6	4 10	17	6 3	11 4·5
Carbine { Common ..	·61	3 1	4 4·5	13	5 5·5	8 5
Carbine { Musq. Bore	·76	2 2	3 5	15	4 8	8 14·5
Rifle	·61	2 6	3 10	17	5 3	10 5
Pistol .. { Musq. Bore	·76	9		—		3 8
Pistol .. { Carb. do..	·61	9		—		2 8

ARTILLERY.

The materiel of artillery is classed into field, siege, and garrison artillery.

I.—OF FIELD ARTILLERY.

Field artillery was formerly divided into three varieties, viz.—battalion guns, horse artillery, and the artillery of the park.

The battalion guns were attached to regiments or battalions of infantry, two to each corps, and took part in all their manœuvres. This practice of assigning guns to particular regiments or battalions, is now, however, discontinued; and the whole of the artillery accompanying an army in the field, is formed into field batteries and batteries of horse artillery. The proportion of ordnance for these batteries varies according to the calibre of the guns to be employed, and is regulated by the following scale.

Proportion of Ordnance, &c. determined according to the Calibre used, for a Field or Horse Artillery Battery of each Nature:—

ORDNANCE AND CARRIAGES.			Nature of Battery					
			18-Pr.	12-Pr.	9-Pr.	6-Pr. Heav.	6-Pr. Light.	3-Pr. Heav.
Ordnance..	18-Pounder, Iron......		3	—	—	—	—	—
	12-Ditto, Brass......		—	5	—	—	—	—
	9-Ditto, Ditto......		—	—	5	—	—	—
	6-Ditto, Ditto......		—	—	—	5	5	—
	3-Ditto, Ditto......		—	—	—	—	—	5
	8-Inch How. Iron		1	—	—	—	—	—
	24-Por. Do. Brass....		—	1	1	1	—	—
	12-Do. Do. Ditto....		—	—	—	—	1	1
Total of Ordnance for each Battery			4	6	6	6	6	6
Carriages..	Spare Carriages		1	1	1	1	1	1
	Wag.	Am. Limber	13	12	9	8	8	7
		Forge	1	1	1	1	1	1
		Store	2	2	1	1	1	1
		Platform	1	—	—	—	—	—
	Store Carts		1	1	1	1	1	1
Total of Carriages for each Battery			19	17	13	12	12	11

This system of forming field artillery into batteries, was adopted upon the recommendation of the late Brigade-Major Spearman, under whose superintendance the first batteries, or brigades, as they were then called, were equipped and organized. The arrangement is founded upon the supposition that the condensed fire of the batteries produces a more destructive effect than could be expected from the divided action of the battalion guns; and the change is justly regarded as one of the most important improvements in the art of modern warfare.

The following are the Proportions of Ammunition and Laboratory Stores, carried with each Nature of Field Ordnance:—

DESCRIPTION OF AMMUNITION AND STORES.	Nature of Ordnance.								
	18 Pounder.	12-Pounder.	9-Pounder.	6-Pounder, Heavy.	6-Pounder, Light.	3-Pounder, Heavy.	8-Inch Howitzer.	24-Pounder, Howitzer.	12-Pounder, Howitzer.
Shot .. Round	36	60	86	150	149	272	—	—	—
Shot .. Case, Common	6	10	16	20	19	44	—	8	8
Shot .. Case, Spherical	12	28	24	30	26	—	13	42	68
Shells—Common—Empty	—	—	—	—	—	—	12	32	48
Carcasses—Round—Fixed	—	—	—	—	—	—	3	2	2
Flannel Cartridges .... Charges (Filled) .. 6 lbs.	42	—	—	—	—	—	—	—	—
4½	12	—	—	—	—	—	—	—	—
4	—	98	—	—	—	—	28	—	—
3	—	—	126	—	—	—	—	—	—
2½	—	—	—	—	—	—	24	84	—
2	—	—	—	200	—	—	—	—	—
1½	—	—	—	—	194	—	—	—	—
1¼	—	—	—	—	—	—	—	—	128
1	—	—	—	—	—	316	—	—	—
Flannel Cartridges .. Bursters (Filled) 1 lb. 14 oz.	—	—	—	—	—	—	12	—	—
15	—	—	—	—	—	—	13	—	—
10	—	—	—	—	—	—	—	32	—
6	—	—	—	—	—	—	—	42	—
5	12	—	—	—	—	—	—	—	12
4½	—	22	—	—	—	—	—	—	20
3½	—	—	24	—	—	—	—	—	—
2½	—	—	—	30	26	—	—	—	—
Flannel Cartridges .. Empty	50	100	100	100	100	100	50	100	100
Quick-match, a length of 10 yards in a clue	1	1	1	1	1	1	1	1	1
Tubes, Brass	100	200	200	300	300	400	300	200	200
Portfires	12	24	24	30	30	36	12	24	24
Tube-pockets, Leather, with Straps	1	2	2	2	2	2	1	2	2
Portfire Sticks	2	2	2	2	2	2	2	4	4
Fuzes .. For Spherical Case, Cut .... ·4	12	28	24	30	26	—	13	42	68
·6	12	28	24	30	26	—	13	42	68
·8	12	28	24	30	26	—	13	42	68
Uncut	12	28	24	30	26	—	13	42	68
Fuzes .. Common graduated	—	—	—	—	—	—	15	40	60
Tin Boxes, with Straps for Spherical Fuzes .. White, for ·4	1	2	2	2	2	—	1	2	2
Blue, for ·6	1	2	2	2	2	—	1	2	2
Black, for ·8	1	2	2	2	2	—	1	2	2
Cutting Knives and Saws in one	1	2	2	2	2	—	1	2	2
Scissors, pairs	1	1	1	1	1	1	1	1	1
Thumb-stalls	2	4	4	4	4	2	2	4	4

Proportions of Ammunition and Laboratory Stores.—Continued.

DESCRIPTION OF AMMUNITION AND STORES.	Nature of Ordnance.								
	18-Pounder.	12-Pounder.	9-Pounder.	6-Pounder, Heavy.	6-Pounder, Light.	3-Pounder, Heavy.	8-Inch Howitzer.	24-Pounder Howitzer.	12-Pounder Howitzer.
Mallets	1	2	2	2	2	—	1	2	2
Setters	2	4	4	4	4	—	2	4	4
Fuze Augers	1	2	2	2	2	—	1	2	2
Files, three-square	1	2	2	2	2	—	1	2	2
Rasps, half-round	1	1	1	1	1	—	1	1	1
Box Rules	1	1	1	1	1	—	1	1	1
Pincers, Iron, pairs	1	1	1	1	1	—	1	1	1
Compasses, pairs	1	1	1	1	1	—	1	1	1
Quadrants / Perpendiculars } of each	1	—	—	—	—	—	1	—	—
Cork-screws	1	2	2	2	2	—	1	2	2
Tin Funnels	1	2	2	2	2	—	1	2	2
Scrapers for Shells	1	2	2	2	2	—	1	2	2
Slow-match, skeins	2	3	3	3	3	3	2	3	3
Linstocks	2	—	—	—	—	—	2	—	—
Powder Horns	2	—	—	—	—	—	2	—	—

Distribution of the above proportion of ammunition in the limber and waggon ammunition boxes of field guns and howitzers, together with the distribution, in the reserve waggons, of the additional proportion judged necessary to accompany each battery :—

18-POUNDER GUN, IRON.

DISTRIBUTION.			Nature of Ammunition. Rd. Shot.	Case. Com.	Case. Spher.	Total.
Waggon.	Limber 2 Boxes		12	6	6	24
	Body	Fore	9	—	6	15
		Hind	15	—	—	15
Total with Waggon			36	6	12	54
Reserve Waggons		First	36	6	12	54
		Second	42	—	12	54
Total per Gun			114	12	36	162

Nine waggons, per battery of 5 guns, carrying 162 rounds of ammunition, per gun.

MEDIUM 12-POUNDER, BRASS.

DISTRIBUTION.			Nature of Ammunition. Rd. Shot.	Case. Com.	Case. Spher.	Total.
Gun Limber, 2 Boxes			6	6	6	18
Waggon.	Limber 2 Boxes		18	4	10	32
	Body	Fore	18	—	6	24
		Hind	18	—	6	24
Total with the Gun and Waggon			60	10	28	98
Reserve Waggon			54	4	22	80
Total per Gun			114	14	50	178

Ten waggons, per battery of 5 guns, carrying 178 rounds of ammunition per gun.

9-POUNDER, BRASS.

DISTRIBUTION.	Nature of Ammunition.			Total.
	Rd. Shot.	Case.		
		Com.	Spher.	
Gun Limber, 2 Boxes............	16	8	8	32
Waggon.... Limber, 2 Boxes....	16	8	8	32
Waggon.... Body .. Fore ..	22	—	8	30
Waggon.... Body .. Hind ..	32	—	—	32
Total with the Gun and Waggon..	86	16	24	126
Reserve. Two Waggons for the 5 Guns...	—	—	—	—
Reserve. Rd. Com. Sph. Total / 140 16 32 188 Per Gun	28	3	6	37
Total per Gun	114	19	30	163

Seven waggons, per battery of 5 guns, carrying 163 rounds of ammunition per gun.

HEAVY 6-POUNDER, BRASS.

DISTRIBUTION.	Nature of Ammunition.			Total.
	Rd. Shot.	Case.		
		Com.	Spher.	
Gun Limber, 2 Boxes	30	10	10	50
Waggon.... Limber, 2 Boxes....	30	10	10	50
Waggon.... Body .. Fore ..	40	—	10	50
Waggon.... Body .. Hind ..	50	—	—	50
Total with the Gun and Waggon..	150	20	30	200
Reserve. One Waggon for the 5 Guns..	—	—	—	—
Reserve. Rd. Com. Sph. Total / 120 10 20 150 Per Gun	24	2	4	30
Total per Gun	174	22	34	230

Six waggons, per battery of 5 guns, carrying 230 rounds of ammunition per gun.

LIGHT 6-POUNDER, BRASS.

DISTRIBUTION.	Nature of Ammunition.			Total.
	Rd. Shot.	Case.		
		Com.	Spher.	
Gun { Axletree, 1 Box	3	3	—	6
Gun { Limber, 2 Boxes	24	8	8	40
Waggon { Limber, 2 Boxes....	32	8	8	48
Waggon { Body .... { Fore..	40	—	10	50
Waggon { Body .... { Hind..	50	—	—	50
Total with Gun and Waggon ..	149	19	26	194
Reserve. { One Waggon for the 5 Guns ..	—	—	—	—
Reserve. { Rd. Com. Sph. Total 114 8 18 140 } Per Gun	22	1	3	26
Total per Gun	171	20	29	220

Six waggons, per battery of 5 guns, carrying 220 rounds of ammunition, per gun.

HEAVY 3-POUNDER, BRASS.

DISTRIBUTION.	Nature Ammunit.		Total.
	Rd. Shot.	Case.	
Gun { Axletree, 1 Box...............	4	4	8
Gun { Limber, 2 Boxes	50	20	70
Waggon { Limber, 2 Boxes	50	20	70
Waggon { Body .. { Fore	84	—	84
Waggon { Body .. { Hind	84	—	84
Total per Gun	272	44	316

No reserve waggons. 316 rounds of ammunition per gun.

8-INCH HOWITZER, IRON.

DISTRIBUTION.			Nature of Ammunition.				
				Case.			
			Shells.	Com.	Spher.	Carcasses.	Total.
Waggon.	Limber, 2 Boxes.		6	—	6	—	12
	Body.	Fore ..	3	—	5	3	8
		Hind ..	3	3	2	—	8
Total with Waggon			12	3	13	—	28
Reserve Waggons, 3, similar..			36	9	39	—	84
Total per Howitzer..........			48	12	52	—	112

Four waggons to each howitzer, carrying 112 rounds of ammunition.

24-POUNDER, OF HEAVY $5\frac{1}{2}$-INCH HOWITZER, BRASS.

DISTRIBUTION.			Nature of Ammunition.				
				Case.			
			Shells.	Com.	Spher.	Carcasses.	Total.
Howitzer, Limber, 2 Boxes ..			8	4	12	—	24
Waggon..	Limber, 2 Boxes.		8	4	12	—	24
	Body..	Fore ..	8	—	8	2	18
		Hind ..	8	—	10	—	18
Total, with How. and Waggon			32	8	42	2	84
Reserve Waggon............			24	4	30	2	60
Total per Howitzer..........			56	12	72	4	144

Two waggons to each howitzer, carrying 144 rounds of ammunition.

The light $5\frac{1}{2}$-inch Howitzer, from the small velocity of its projectile, and the uncertainty of its range and direction, is of late years disused.

12-POUNDER, HOWITZER, BRASS.

DISTRIBUTION.	Nature of Ammunition.				Total.
	Shells.	Case. Com.	Case. Spher.	Carcasses.	
Howitzer, Limber, 2 Boxes ..	12	4	20	—	36
Waggon.. Limber, 2 Boxes.	12	4	20	—	36
Waggon.. Body.. Fore ..	12	—	12	2	28
Waggon.. Body.. Hind ..	12	—	16	—	28
Total, with How. and Waggon	48	8	68	4	128
Reserve Waggon	36	4	48	4	92
Total per Howitzer..........	84	12	116	8	220

Two waggons to each howitzer, carrying 220 rounds of ammunition.

The flannel cartridges and small stores are distributed in the several boxes, in equal proportions with the above, according to circumstances.

The following are the Proportions of Stores carried with each of the Waggons accompanying a Field Battery.

	DESCRIPTION OF STORES.		18-Pounder.	12-Pr. Medm. Light	9-Pounder. 6-Pr. Heavy.	6-Pr. Light.	3-Pr. Heavy.
On each Ammunition Limb. Wag	Picket Rope, 3-Inch, yards		25	25	25	25	25
	Wood Mauls		2	2	2	2	2
	Picket Posts		4	4	4	4	4
	Pieces of 2-In. rope, ea. 5 yds.		2	2	2	2	2
	Horse-shoes, sets, with 3 sets of nails to each		40	40	40	40	40
With the Forge Waggon.	Bellows, pairs		1	1	1	1	1
	Anvil, with Block		1	1	1	1	1
	Coals, Bushels		2	2	2	2	2
	Smith's Tools in the Limber Box, consisting of						
	Tongs, pairs		2	2	2	2	2
	Slices		1	1	1	1	1
	Ladles		1	1	1	1	1
	Vices	Standing	1	1	1	1	1
		Hand	1	1	1	1	1
	Hammers	Sledge	1	1	1	1	1
		Hand	1	1	1	1	1
		Rivetting	1	1	1	1	1
	Cold Chisels	Rod	2	2	2	2	2
		Hand	2	2	2	2	2
	Punches	Rod	2	2	2	2	2
		Hand	2	2	2	2	2
	Screw Drivers		1	1	1	1	1
	Rasps	Half-round	6	6	6	6	6
		Round	6	6	6	6	6
		Flat	6	6	6	6	6
		Three-square	6	6	6	6	6
	Shoeing Tools, 1 Set for each Smith		1	1	1	1	1

Nature of Battery.

Proportions of Stores, &c.—Continued.

DESCRIPTION OF STORES.			Nature of Battery.				
			18-Pr. Iron.	12-Pr. { Medm. / Light.	9-Pounder, or 6-Pr. Heavy.	6-Pr. Light.	3-Pr. Heavy.
With the Spare Gun and Wheel Carriage.	Wheels	Heavy	1	1	1	—	—
		Limber	1	—	—	—	—
		Light	3	2	2	3	3
	Iron Axles	Whole, Heavy	1	1	1	—	—
		Arms, Light	2	2	2	2	2
	Hand-spikes	Common	16	—	—	—	—
		Traversing	2	2	2	2	2
	Shafts, complete		2	2	2	2	2
	Pintails		1	1	—	—	—
	Limber Hooks		1	1	1	1	1
	Driving Bolts		1	1	1	1	1
	Perches		1	1	1	1	1
	Nose-plates		1	1	1	1	1
	Trail-plate Eyes		1	1	1	1	1
	Elevating Screws		1	1	1	1	1
	Staples for Side Arms		—	20	20	20	20
	Linchpins	Heavy	4	6	6	—	—
		Light	10	10	10	8	8
	Wheeler's Tools in the Limber Box, consisting of						
	Pincers, pairs		1	1	1	1	1
	Broad Axes		1	1	1	1	1
	Adzes		1	1	1	1	1
	Draw Shaves		1	1	1	1	1
	Spoke Shaves		2	2	2	2	2
	Hammers	Shoeing	1	1	1	1	1
		Rivetting	1	1	1	1	1
		Claw	1	1	1	1	1
	Drive Pins		2	2	2	2	2
	Hand Punches		2	2	2	2	2
	Cold Chisels, Hand		2	2	2	2	2

Proportions of Stores, &c.—Continued.

	DESCRIPTION OF STORES.	Nature of Battery. 18-Pr. Iron.	12-Pr. Medm. / Light.	9-Pounder, or 6-Pr. Heavy.	6-Pr. Light.	3-Pr. Heavy.
With the Spare Gun and Wheel Carriage.	Augers — 1 Inch	2	2	2	2	2
	Augers — $\frac{3}{4}$ do.	2	2	2	2	2
	Augers — $\frac{5}{8}$ do.	1	1	1	1	1
	Augers — $\frac{1}{2}$ do.	1	1	1	1	1
	Spike Bitts, of sorts	4	4	4	4	4
	Gimblets, nests	1	1	1	1	1
	Planes — Jack	1	1	1	1	1
	Planes — Smoothing	1	1	1	1	1
	Wrench Hammers, strong	1	1	1	1	1
	Saws — Hand	1	1	1	1	1
	Saws — Tenon	1	1	1	1	1
	Rules, 2 feet	1	1	1	1	1
	Iron Crows, 2 feet	1	1	1	1	1
	Gouges — Picking	1	1	1	1	1
	Gouges — Boxing	1	1	1	1	1
	Screw Drivers, strong	1	1	1	1	1
	Linchpins	12	12	12	12	12
	Compasses, pairs	1	1	1	1	1
	Rag-stones	1	1	1	1	1
	Oil-stones	1	1	1	1	1
	Tool Bags	1	1	1	1	1
	Chalk Lines	1	1	1	1	1
	Brass Reels	1	1	1	1	1
	Socket Chisels — 2 Inch	1	1	1	1	1
	Socket Chisels — $1\frac{1}{2}$ do.	1	1	1	1	1
	Socket Chisels — 1 do.	1	1	1	1	1
	Socket Chisels — $\frac{3}{4}$ do.	1	1	1	1	1
	Socket Chisels — $\frac{1}{2}$ do.	1	1	1	1	1
	Gyn, complete with Blocks, Slings, and Falls	1	—	—	—	—

Proportions of Stores, &c.—Continued.

DESCRIPTION OF STORES.	Nature of Battery.				
	18-Pr. Iron.	12-Pr. { Medm. Light.	9-Pounder, or 6-Pr. Heavy.	6-Pr. Light.	3-Pr. Heavy.
With the Store Waggon. — Tarred Rope, 3 Inch, yards	25	25	25	25	25
Lashing Rope.. { Coils	1	½	—	—	—
Lashing Rope.. { Yards........	—	—	25	25	25
Grease, kegs	8	8	8	8	8
Iron, Cwts. { Flat	½	½	½	½	½
Iron, Cwts. { Square	¼	¼	¼	¼	¼
Iron, Cwts. { Rod	¼	¼	¼	¼	¼
Iron, Cwts. { Round	¼	¼	¼	¼	¼
Iron, Cwts. { Hooping.........	¼	¼	¼	¼	¼
Steel Cwts. { Sheer	¼	¼	¼	¼	¼
Steel Cwts. { Blister	¼	¼	¼	¼	¼
Horse-shoes, Sets, 3 Sets of Nails to each	40	40	40	40	40
Lanthorns, Dark	3	3	3	3	3
Candles, lbs..................	12	12	12	12	12
Spare. { Leather Buckets	6	6	6	6	6
Spare. { Nose Bags, $\frac{1}{10}$ the No. of Horses					
Spare. { Forage Cords, Sets	6	6	6	6	6
Spare. { Reaping Hooks............	6	6	6	6	6
Scythes	6	6	6	6	6
Rag-stones for Scythes	6	6	6	6	6
Spare. { Gun Wheels { Heavy	—	1	1	—	—
Spare. { Gun Wheels { Light	1	—	—	1	1
Spare. { In the Rough. { Fellies of Sorts..	12	9	9	9	9
Spare. { In the Rough. { Spokes	24	18	18	18	18
Spare. { In the Rough. { Splinter Bars....	1	1	1	1	1
Streaks of Sorts...............	9	6	6	6	6
Copper Measures, 4lb. to ¼lb.	2	1	1	1	1

Proportions of Stores, &c.—Continued.

	DESCRIPTION OF STORES.	Nature of Battery. 18-Pr. Iron.	12-Pr. { Medm. / Light	9-Founder, or 6-Pr. Heavy.	6-Pr. Light.	3-Pr. Heavy.
With the Store Waggon.	Steelyard, with Weight to Weigh 2 Cwts.........	1	1	1	1	1
	Collar-Maker's Materials, consisting of					
	Hides { Black { Heavy..	1	1	1	1	1
	Hides { Black { Light..	1	1	1	1	1
	Hides { White Horse....	1	1	1	1	1
	Bazils, dozens { Black....	3	3	3	2	2
	Bazils, dozens { Brown ...	3	3	3	2	2
	Wax, lbs.... { Black....	4	4	4	4	4
	Wax, lbs.... { Bees	2	2	2	2	2
	Thread, lbs... { Collar....	6	6	6	4	4
	Thread, lbs... { Hemp	10	10	10	8	8
	Bristles, ozs.	8	8	8	6	6
	Whipcord, lbs.	2	2	2	2	2
	Whips, short............	6	6	6	6	6
	Doe's Hair, lbs..........	28	28	28	28	28
	Serge, yards	20	20	20	20	20
	Girth Web, ditto	20	20	20	20	20
	Brushes, Hard	12	12	12	12	12
	Oil, gallons { Sweet......	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$
	Oil, gallons { Neat	10	10	10	8	8
	Straps for Side Arms......	—	6	6	6	6
	Black Iron Buckles, dozens { 2 Inch ..	2	2	2	2	3
	Black Iron Buckles, dozens { $1\frac{3}{4}$	3	3	3	3	3
	Black Iron Buckles, dozens { $1\frac{1}{2}$	3	3	3	3	3
	Black Iron Buckles, dozens { 1	3	3	3	3	3
	Black Iron Buckles, dozens { $\frac{3}{4}$	3	3	3	3	3
	Screws of Sorts, dozens ..	8	8	8	8	8
	Streak of Sorts..........	100	100	100	100	100

Proportions of Stores, &c.—Continued.

DESCRIPTION OF STORES.		Nature of Battery. 18-Pr. Iron.	12-Pr. { Medm. / Light.	9-Pounder, or 6-Pr. Heavy.	6-Pr. Light.	3-Pr. Heavy.
With the Store Waggon. Nails. Clasp	40penny	200	—	—	—	—
	30	300	—	—	—	—
	20	300	300	300	300	300
	10	600	600	600	600	600
	6	600	600	600	600	600
Clout, the Larger Sort, Chisel Pointed.	6penny	600	600	600	600	600
	4	600	600	600	600	600
	3	600	600	600	600	600
	2	600	600	600	600	600
Tacks of Sorts		1500	1000	1000	1000	1000
Collar-Maker's Tools in the Limber Box, consisting of						
Lead for Punching, Small..		1	1	1	1	1
Saddlers, Hammers		1	1	1	1	1
Knives .. { Hand		1	1	1	1	1
{ Cutting		1	1	1	1	1
Mallets		1	1	1	1	1
Shears, pairs		1	1	1	1	1
Clams, do...............		1	1	1	1	1
Rag-stones...............		1	1	1	1	1
Rules, 2 feet		1	1	1	1	1
Marline Spikes		1	1	1	1	1
Hand Iron..............		1	1	1	1	1
Needles { Collar		6	6	6	6	6
{ Sewing		24	24	24	24	24
Awls { Driving { Large		1	1	1	1	1
{ Driving { Small		1	1	1	1	1
{ Stitching of Sorts		12	12	12	12	12
Punches...............		1	1	1	1	1
Pincers, pairs		1	1	1	1	1
Nippers do.		1	1	1	1	1
Stuffing Sticks		2	2	2	2	2

The following are further Proportions of General Stores for Six Months' Consumption of a Field Battery already Equipped:—

DESCRIPTION OF STORES.	Nature of Battery.		
	18-Pr.	Heavy.	Light.
Gyn, complete with Blocks, Slings, and Falls	1	—	—
Claw Hammers	2	2	2
Intrenching Tools — Felling Axes	3	3	3
Intrenching Tools — Pick Axes	3	3	3
Intrenching Tools — Hand Bills	3	3	3
Intrenching Tools — Spades	6	6	6
Tarred Rope, 2 Inch....Coils	1	1	1
Ratline, or Lashing Rope, ditto	1	1	1
Spunyarn .... ditto	1	1	1
Grease........ kegs	20	16	16
Horse Harness, Rope — Wheel	2	2	2
Horse Harness, Rope — Leader	8	4	4
Riding Saddles and Bridles, of each, spare	2	2	2
Whips, Short	5	3	3
Leggins	5	3	3
Head Stall Halters, with Chain Reins	10	6	6
Iron Hames, Spare	4	3	2
Spare. — Nose Bags, Canvas, ¼ the No. of Horses			
Spare. — Corn Bags for 2 days' Corn, ⅙ per Mounted Man			
Spare. — Corn Sacks, 1 per Carriage			
Spare. — Forage Cords, Sets, 1 for 2 Drivers			
Spikes, Spring and Common, of each	2	2	2
Priming Irons, Sets	2	2	2
Park Pickets	60	50	44
Wood Mauls	6	6	6
Lanthorns — Muscovy	4	2	2
Lanthorns — Dark	4	2	2
Candles, lbs.	36	36	36
Slow-match, cwts.	1	1	1

Further Proportions of Stores, &c.—Continued.

DESCRIPTION OF STORES.	Nature of Battery.		
	18-Pr.	Heavy.	Light.
Leather Buckets	50	50	40
Wadmiltilts	1	1	1
Hair Cloths	1	1	1
Tarpaulins for Covering Ammunition	1	1	1
Copper Scales with Beams	1	1	1
Brass Weights, 4lb. Piles	1	1	1
For the Smiths — Steel cwts. — Sheer	¼	¼	¼
For the Smiths — Steel cwts. — Blister	¼	¼	¼
For the Smiths — Iron, cwts. — Flat ½ Inch	½	½	½
For the Smiths — Iron, cwts. — Square	½	½	½
For the Smiths — Iron, cwts. — Rod	½	½	½
For the Smiths — Iron, cwts. — Round Bolt	½	½	½
For the Smiths — Iron, cwts. — Hooping	½	½	½
For the Smiths — Coals, Chaldrons	¾	¾	¾
For the Smiths — Horse Shoes, 3 Sets Nails each, at 6 Sets per Horse			
For the Smiths — Shoeing Tools, Spare Sets	1	1	1
For the Smiths — Smith's Tools in a Box / Spare Set for each Shoeing Smith	1	1	1
For the Wheelers — Spare — Wheels — Gun — Heavy			
For the Wheelers — Spare — Wheels — Gun — Light			
For the Wheelers — Spare — Wheels — Limber			
For the Wheelers — Spare — Wheels — Waggon — Fore			
For the Wheelers — Spare — Wheels — Waggon — Hind			
For the Wheelers — Spare — In the Rough — Fellies			
For the Wheelers — Spare — In the Rough — Spokes			
For the Wheelers — Spare — In the Rough — Splinter Bars			
For the Wheelers — Spare — In the Rough — Shafts			
For the Wheelers — Spare — In the Rough — Guides — Fore			
For the Wheelers — Spare — In the Rough — Guides — Hind			
For the Wheelers — Spare — In the Rough — Underpoles			
For the Wheelers — Spare — In the Rough — Perches			
For the Wheelers — Iron Axles			

Further Proportions of Stores, &c.—Continued.

	DESCRIPTION OF STORES.	Nature of Battery. 18-Pr.	Heavy.	Light.
For the Wheelers.	Shafts, complete			
	Hand-spikes — Common, short	20	—	—
	Hand-spikes — Traversing	—	6	6
	Iron Crows	4	—	—
	Screws of Sorts	50	25	25
	Nails, Streak	2000	2000	2000
	Nails — Clasp — 40 Penny	500	—	—
	Nails — Clasp — 30	500	—	—
	Nails — Clasp — 20	1000	1000	1000
	Nails — Clasp — 10	3000	2000	1000
	Nails — Clasp — 6	2000	2000	1000
	Nails — Clout, the larger sized, chisel pointed — 6	2000	2000	2000
	Nails — Clout, the larger sized, chisel pointed — 4	2000	2000	2000
	Nails — Clout, the larger sized, chisel pointed — 3	2000	2000	2000
	Nails — Clout, the larger sized, chisel pointed — 2	2000	2000	2000
	Tacks of Sorts	5000	4000	3000
For the Collar-Makers.	Hides — Black — Heavy	3	3	3
	Hides — Black — Light	3	3	3
	Hides — White, Horse	3	3	3
	Bazils, dozens — Black	9	9	6
	Bazils, dozens — Brown	9	9	6
	Wax, lbs. — Black	6	6	6
	Wax, lbs. — Bees	6	6	6
	Bristles, ozs	24	24	18
	Thread, lbs. — Collar	18	18	12
	Thread, lbs. — Hemp	30	30	24
	Thread, lbs. — Whited Brown	2	2	2
	Whipcord, lbs.	6	6	6
	Doe's Hair, cwt.	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
	Serge, yards	60	60	60
	Brushes, Sets — Hard	36	36	36
	Brushes, Sets — Soft	36	36	36
	Brushes, Sets — Water	36	36	36

Further Proportions of Stores, &c.—Continued.

		DESCRIPTION OF STORES.		Nature of Battery. 18-Pr.	Heavy.	Light.
For the Collar-Makers.	Oil, gallons	Sweet		1	1	1
		Neat		30	30	24
		Linseed		6	6	6
	Turpentine, gallons			1	1	1
	Paint, Lead Colour, cwts.			$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
	Paint Brushes, Large and Small, each			6	6	6
	Straps for Side Arms			18	18	18
	Black Iron Buckles, dozens	2 Inch		9	9	9
		$1\frac{3}{4}$ do.		9	9	9
		$1\frac{1}{2}$ do.		9	9	9
		1 do.		9	9	9
		$\frac{3}{4}$ do.		9	9	9
Camp Equipage, in the Proportion as heretofore						
For the Collar-Maker.	Collar-Maker's Tools in a Box, Spare Sets.			1	1	1
For the Wheeler.	Wheeler's Tools in a Box, Spare Sets.			1	1	1
Blankets, Canteens, Haversacks,	One for each Man, and one-fourth Spare.					

NECESSARY CONSIDERATIONS IN EQUIPPING AND ORGANIZING A FORCE OF FIELD ARTILLERY FOR ACTIVE SERVICE.

When an army is to take the field, several considerations must be attended to in apportioning the number and calibre of the batteries to accompany it:—As the face, features, and general nature, mountainous

or otherwise, of the country which is to form the theatre of war;—the state of its roads, and the resources which it can supply for the means of transport;—the force and description of troops composing the army;—the nature of the war, whether offensive or defensive; —and, lastly, the intended plan of operations.

In carrying on offensive operations in a champaign country with good roads and facility of transport, the artillery should consist of 9-pounder batteries, to which a few 18 or 12-pounders should be added, to form, on occasion, batteries of position. There should likewise be one or more batteries of a lighter calibre, to accompany any corps that may be destined by rapid marches, to intercept the enemy's convoys or detachments. In mountainous or deep hilly countries, the artillery should not be composed of heavier ordnance than the 6-pounder battery; but an exact topographical acquaintance with the nature of the country is absolutely necessary, and, in short, affords the only satisfactory guide for judging of the most appropriate calibres to be employed.

When an army is to remain upon the defensive in a country in which the roads are only tolerable, and the probability of being obliged to undertake long and rapid marches is not great, the artillery should be composed of a heavier description of battery than would accompany an army acting offensively in the same country. But, if this defensive system be carried on in a strong country, where the means of transport

are attended with difficulty, and long and rapid marches may become indispensably necessary, the batteries must be so constituted as to adapt them to these several circumstances; otherwise, the artillery must retard the army in its operations, instead of contributing to the attainment of the object in view.

The following historical examples of the relative proportions of artillery, with different armies, acting in various countries, may, with the assistance of good topographical maps, enable an officer to form a tolerably correct judgment upon this important study of his profession.

The Austrian army, under the command of the Archduke Charles, in the campaign of Asperne, Essling, and Wagram, consisted of about seventy-five thousand men, to whom were attached eighteen batteries of brigade, thirteen of position, and eleven of horse artillery:—forming the proportion of one piece of ordnance to two hundred and sixty men nearly.

The grand French army, for the invasion of Russia, under Napoleon,—not including the Austrian contingent,—consisted of four hundred thousand infantry, sixty thousand cavalry, and twelve hundred pieces of artillery:—being in the proportion of one gun to three hundred and eighty-three men.

The allied British and Portuguese army in the field

in Spain, May, 1813, consisted of sixty-five thousand men, and one hundred and two pieces of artillery, including the reserve :—being in the proportion of one gun to six hundred and twenty-two men nearly.

General Dombrowski's division of six thousand men, on the Berezina, in November, 1812, had twenty pieces of artillery ;—or one gun to three hundred men.

The Prussian contingent, under the command of General D'York, of the grand French army for the invasion of Russia, consisted of twenty thousand men and sixty pieces of artillery : —being in the proportion of one gun to three hundred and thirty-three men nearly.

Napoleon, in 1813, had fourteen hundred pieces of artillery to three hundred thousand men ;—or one gun to two hundred nearly.

In 1815 his army consisted, as nearly as can be ascertained, by a comparison of several accounts of the campaign, of one hundred and thirty thousand infantry, twenty thousand cavalry, and three hundred pieces of artillery ;—or one gun to five hundred men.

Marshal Beresford, at the battle of Albuhera, had twenty-nine thousand men, and thirty-two pieces of artillery ;—being one gun to nine hundred men.

Marshal Soult, in the same action, had twenty-three thousand men, and forty pieces of artillery;—or one gun to five hundred and seventy-five men.

It appears that the French armies united on the Tormes, in December, 1812, amounted to eighty thousand men, and two hundred pieces of artillery:—being in the proportion of one gun to four hundred men.

Sir Rowland Hill's *corps-d'armée* of twenty thousand men had twenty-four pieces of artillery attached to it;—or one gun to eight hundred and thirty-three men.

The French army at Vittoria consisted of fifty thousand men, and one hundred and fifty-two pieces of artillery:—being one gun to three hundred and twenty-five men.

General L'Espinasse supposes a division of an army to consist of twelve thousand men, including a regiment of dragoons, and another of hussars; to which he allots three batteries of horse, and three of field artillery, each consisting of six pieces of ordnance. A battery of horse, and another of field artillery, are at all times to be up with the army; two batteries, similarly armed with the two in activity, are to remain with the park; and the remaining two, also appointed in like manner, should be in depôt in rear of the army. These proportions of artillery to infantry L'Espinasse

states, are precisely those adopted, with the approbation of Bonaparte, in the Italian campaigns.

II.—Of Siege Artillery.

In the formation of a field equipment, it is impossible to foresee what proportion of ordnance may be best adapted to each particular army, or upon what particular ground it will have to act; in the formation of a battering train, on the contrary, the basis of its composition is given from the moment at which we are acquainted with the place to be invested.

NECESSARY CONSIDERATIONS IN PREPARING AN ESTIMATE OF THE PROPORTION OF ORDNANCE AND AMMUNITION REQUIRED FOR THE SIEGE OF A FORTIFIED PLACE.

When it is intended to besiege a fortress, the first duty of the commanding officer of artillery is to prepare an estimate of the quantity of ordnance and ammunition required for that purpose. To enable him to make this calculation, with accuracy and precision, he must be master of certain data:—that is to say, the commander of the forces, or general charged with the direction of the siege, should communicate to him a plan of the fortifications and environs of the place, accompanied by such profiles and remarks as may enable him, in conjunction with the commanding engineer, to ascertain which front or fronts are most

assailable, with the advantages and disadvantages attending each attack, as well with respect to the works, as to the nature of the soil where the trenches must be opened, and the several heights and hollows in the vicinity of the town. He should also, if possible, be informed whether the place is amply supplied with artillery, ammunition, &c. But the most important information he can receive on this point is the strength of the garrison; for if we consider, for a moment, that it is the number of troops alone which animate and give life to the means of defence, and that without them, the strongest works can only oppose an inert and passive resistance, we may conclude, in nine cases out of ten, the degree of value and importance which are attached to the place. It will thus be easy to form a tolerably accurate opinion of its means of defence, and the resistance to be expected; for it is not to be presumed that any government would shut up a brave and numerous force in an ill-fortified and badly provisioned place, at the risk of seeing such a garrison sacrificed after a short resistance.

But should it be impossible to procure information on these points before hand, the requisite proportion of ordnance and ammunition must be regulated upon the general principles of attack. For this purpose, the officer intrusted to prepare the estimate should endeavour to ascertain—according to the fundamental maxim of all besiegers—against which front, or fronts

the attack can be made, *with the least exposure and greatest expedition.* He should examine whether the siege can be most advantageously carried on by regular approaches;—by taking advantage of any defect in the situation, which may enable him to break ground close to the works;—or by battering them from a distance.

By the aid of this investigation, and of the following general principles, the quantity of ordnance and ammunition required for the siege of any place, may be ascertained with the greatest accuracy.

GENERAL PRINCIPLES FOR THE ATTACK OF FORTIFIED PLACES.

1. The number of batteries to be erected against any place, must depend upon the extent of the works embraced by the attack:—there must be a battery to enfilade every face of the works that can, in any way, annoy the besiegers in their approaches.

2. The length of the epaulement of these batteries need not exceed the breadth of the terreplein of the work to be enfiladed; unless circumstances should make it necessary to place some of the guns in a situation to take the work in reverse. Each battery, therefore, will only contain five, or at most eight, guns; to which must be added two more, to enfilade the branches of the opposite covered-way.

3. As the situation of the breaching batteries, in a regular attack, may effectually interfere with the con-

tinued fire of the first or enfilading batteries, the destination of the same artillery is frequently transferred from one purpose to the other.

Having thus ascertained the number of guns required, the following will be their calibres, and the proportion which the remaining ordnance should bear to them :—

Guns.—Of the whole number required :—

24-Pounders	$\frac{2}{3}$
12-Ditto, Long......	$\frac{1}{3}$

Howitzers.—One for every four guns :—

10-Inch...............	$\frac{1}{3}$
8-Ditto	$\frac{2}{3}$

Mortars.—In the proportion of one-twelfth more than the number of guns :—

10-Inch...............	$\frac{2}{13}$
8-Ditto	$\frac{3}{13}$
$5\frac{1}{2}$-Ditto............	$\frac{4}{13}$
$4\frac{2}{5}$-Ditto	$\frac{4}{13}$

In the above proportion of ordnance, it must be observed that, in the guns, the long 12-pounder is proposed instead of the 18-pounder formerly employed, as a gun of this description is conceived to be sufficiently powerful for annoyance, and direct fire, to dismount the enemy's artillery, as well as for firing en-ricochet; and the diminished weight of ammunition is an important advantage attendant upon the employment of the smaller calibre. But it is an arrangement that can be admitted, only in cases where there is an adequate number of 24-pounders, and it

would, therefore, be better, with small equipments, that all the guns should be of the heavy calibre.

The proportion of small mortars should, in no case, be less than that of the heavy mortars and howitzers; but this proportion ought to be augmented in all equipments of less than thirty pieces of ordnance. Indeed, when sent at all, there should be at least twelve of them, to insure the necessary effect. In many cases, a far greater number than is here proposed, could be advantageously used; but this must depend upon the nature of the service on which they are likely to be employed.

In the present instance the Royal and Cœhorn mortars have been taken in equal proportions; and it would be advisable to adhere to this in the larger equipments, particularly when their calibres corresponds with those of the guns; but in small equipments it would be more convenient to confine the arrangement to one calibre, in which case the Royal mortar is preferable, as it possesses the power of being used at a greater distance. But it must, at the same time, be observed, that the Cœhorn, from its lightness and small weight of ammunition, is a more desirable implement to employ in the more advanced parts of the attack.

Having determined the nature and quantity of ordnance required, the following will be the proportion and nature of ammunition.

GUN.

Round Shot.—At 1000 rounds per 24-pounder.
1200 rounds per 12-ditto.

Tier Shot.—At 50 rounds per gun.

Spherical Case.—At 100 rounds per gun.

HOWITZER.

Shells.—At 600 per 10-inch.
300 per 8-ditto.

Spherical Case.—At 300 rounds per 8-inch.

Carcasses.—At 10 per howitzer.

Valenciennes Composition.—At 100 proportions per 10-inch.

MORTAR.

Shells.—At 600 per 10 and 8-inch.
200 per $5\frac{1}{2}$ and $4\frac{2}{5}$ ditto.

Pound Shot—At 50 rounds, of 100 shot each, per 10-inch.

Carcasses.—At 10 per 10 and 8-inch.

Valenciennes Composition.—At 100 proportions per 10-inch.

In the above proportion of ammunition there is an increase of 200 rounds of round shot in favour of the 12-pounders, as the facility of working these guns will, at an easy rate, afford the means of firing more rapidly than from the 24-pounders. The proportion of one-half common shells, and one-half spherical case should always be adhered to for the 8-inch howitzers.

OF THE ARRANGEMENT OF THE ARTILLERY AT A SIEGE.

The first arrangement of the artillery at a siege relates to the different batteries raised near the first parallel to enfilade the faces of the works on the front attacked, which fire on the approaches. If these first batteries be favourably situated, the artillery may be continued in them nearly the whole time of the siege; and will save the erection of any other gun batteries, till the besiegers arrive on the crest of the glacis. It however, frequently happens, from local circumstances, that the besiegers cannot always avail themselves of the most advantageous situations for the first batteries.

There are four situations from which the defences of any face may be destroyed; but not from all with equal facility.

The best positions for the first batteries are perpendicular to the prolongations of the faces of the works to be enfiladed. If these positions cannot be attained, the next that present themselves are on those sides of the prolongations which take the faces in reverse; and under as small angles as possible. From each these situations the guns must fire en-ricochet.

If the ground, or other circumstances, will not admit of either of these situations being occupied by ricochet batteries, the battery to destroy the fire of the face must be without its prolongation, so as to fire obliquely upon the outside of it. The last position, in point of advantage, is directly parallel to the face. From

these two last positions the guns must fire with full charges.

The second, or breaching batteries, are generally placed on the glacis, within 15 or 18 feet of its crest; which space serves as the epaulement; but if the foot of the revetment cannot be seen from this situation, they must be placed in the covered-way, within 15 feet of the counterscarp. These batteries must be sunk to such a depth that the terreplein of the covered-way may coincide with the soles of the embrazures, and are, in fact, but an enlargement of the sap, run for the lodgement on the glacis or in the covered-way. They should contain at least four guns; and if the space between the traverses will not admit of this number, at the usual distances, the guns must be closed to 15 or 12 feet of each other.

The mortars are generally at first arranged in battery, adjoining the first gun batteries, or upon the prolongations of the capitals of the works, in which latter situations they are certainly least exposed.

Upon the establishment of the half parallels, the howitzers are placed in battery in their extremities, to enfilade the branches of the covered-way; and upon the formation of the third parallel, the small mortars are arranged in it, to annoy the besieged in the places of arms.

In the establishment of all these batteries, a great object is to make such an arrangement of them that they do not mask the fire of each other more than

cannot be avoided, and particularly that of the first or ricochet batteries. The aggravation of the inconvenience may very well be prevented till the establishment of the attack on the crest of the glacis, when it becomes in some degree unavoidable; however, even the operations of the glacis may be so arranged, that the ricochet batteries be not masked till the breaching batteries are in a state of great forwardness. For further details on this subject, and for the manner of constructing batteries, see the word Battery, also the words Ricochet, Breach, Magazine, Platform, &c.

III.—Of Garrison Artillery.

The proportion of ordnance, ammunition, stores, &c. required for the defence of a fortified place depends, not only on the particular situation of each individual fortress and its relations with the surrounding country, the system according to which it is fortified, and the species of attack it may be possible to open against it; but likewise on innumerable minor circumstances, each of which may exert an important influence on the defence.

If, for example, one or more of the fronts of a place be covered by an inundation, a marsh, or by any other impassable obstacle, it will manifestly require a much smaller proportion of artillery for its defence, than if it were equally accessible on every front. On the contrary, a maritime fortress which is susceptible of attack

both by sea and land, will require a larger proportion of ordnance supplies than if it were assailable from only one of these points.

It will be seen, therefore, from the above remarks and examples, how impossible it is to lay down any general rules upon this important subject. The only satisfactory plan which an officer, charged with the nice and responsible trust of arming a fortified place, can with security follow, is to examine attentively all parts of the works and of the surrounding country, and to weigh every other circumstance that can in any way influence the defence. He should consider which of its fronts are most vulnerable, and what measures are best adapted to their defence. To effect this with accuracy and precision, he should, after a few days passed in reconnoitering and studying his position, devote his attention to the preparation of a sketch and profiles of the works and surrounding country, as far at least as a mile in every direction, and upon a scale adapted to the features of the ground.

With this map before him, he should recur to those fundamental principles upon which every good attack and defence are founded; and he should be not only thoroughly acquainted with his own particular branch of the service in all its details, but capable of judging, to the fullest extent, of all operations in which the other troops of the garrison can bear their part:—so that every supply may be adequate to its particular

purpose, without deficiency on the one hand, or superfluity on the other.

Thus two extremes, equally prejudicial, will be avoided:—the one of making a provision insufficient for the defence which the fortress is capable of sustaining;—the other of providing such a quantity, that, on the surrender of the place, which, according to the natural order of things, must sooner or later happen, if it be not relieved, a complete arsenal would fall into the enemy's hands. These observations being held in mind, the following maxims will be found of essential assistance:—

GENERAL MAXIMS FOR ARMING FORTIFIED PLACES.

1. The proportion of ordnance, ammunition, and stores should never exceed the quantity absolutely necessary to a brave and resolute defence.

2. Those fronts which are considered susceptible of attack, should be completely armed, and the remaining fronts only in part.

3. There should be for each of the faces of the bastions of such fronts as are deemed liable to attack, 5 or 6 pieces of ordnance; for each of the flanks of these bastions 4; and for the faces of the ravelin, from 5 to 7 pieces of ordnance. When there are lunettes, 4 pieces of ordnance should be reckoned for each, and from 2 to 3 for each of the places of arms of the covered-way.

Supposing, therefore, one front of a place to be

completely armed, the following proportion of ordnance will be required.

For the faces of the bastions from	10 to 12 pieces.
two interior flanks	6 to 8
faces of the ravelin	5 to 7
five places of arms	10 to 15

Total of ordnance, one front, from 33 to 42 pieces.

4. In case of the place being liable to attack on two consecutive fronts, the above proportion should be augmented by one-half; and if on two detached fronts, it should be doubled.

5. Each of the remaining fronts should be provided with such a proportion of its full armament, as will secure it from insult.

Lastly. It will appear from the above maxims, which are deduced from the best authorities, that a hexagon, having only one front exposed to attack, requires from 58 to 68 pieces of ordnance for its defence; and that for more extensive places, from 6 to 8, or at most 10 pieces of ordnance, should be added for each additional front.

The next point to be considered is, the proportion which the several natures of ordnance and their relative calibres should bear to each other; and here it should be remembered, that the higher rates are not the only descriptions capable of being employed to advantage in the defence of a place. There are many cases in which medium guns can oppose an equal resistance with heavier calibres, and they possess the

very important advantage of affording greater facility in transporting them from one situation to another; they also consume less ammunition, and enable the besieged to keep up a more determined and incessant fire.

The following are the proportions usually adhered to in most ordinary cases:—

GUNS.—In the proportion of two-thirds of the whole armament:—

24-Pounders	Two-thirds	One-sixth.
18-Ditto.. ..		Two-sixths.
12-Ditto.. ..		Three-sixths.
9-Pounders	One-third	One-third.
6-Ditto.. ..		Two-thirds.

HOWITZERS.—One for every five guns:—

10-Inch	Two-thirds	One fourth.
8-Ditto		Three-fourths.
24-Pounder..................		One-third.

MORTARS.—In the proportion of one-half more than the number of howitzers:—

10-Inch	One-third	One-third.
8-Ditto ...		Two-thirds.
$5\frac{1}{2}$-Inch ..	Two-thirds	In equal proportions.
$4\frac{2}{5}$-Ditto..		

The above distribution of guns, howitzers, and mortars applies equally to all armaments of not less than sixty pieces of ordnance; and such an armament should, therefore, consist of forty guns, eight howitzers, and twelve mortars. The proportions of the several calibres, except those for the guns, are calculated on a basis of not less than ninety pieces of ordnance; and in all smaller armaments, it would be

advisable to confine the arrangement to two calibres of each nature only.

The following will be the proportion and nature of ammunition for each species of ordnance :—

GUN.

Round Shot.		24-Pounders, at		600	per Gun.
		18	Ditto	760	ditto
		12	Ditto	800	ditto
		9	Ditto	1000	ditto
		6	Ditto	1200	ditto
Case.	*Common.*	24 Pounders, at		40	per Gun.
		18	Ditto	50	ditto
		12	Ditto	60	ditto
		9	Ditto	100	ditto
		6	Ditto	150	ditto
	Spherical.	24-Pounders, at		40	per Gun.
		18	Ditto	50	ditto
		12	Ditto	55	ditto
		9	Ditto	60	ditto
		6	Ditto	60	ditto

HOWITZER.

Shells		10-Inch, at		400	per Howitzer.
		8	Ditto	600	ditto
		24-Pounders,		750	ditto
Case.	*Common.*	10-Inch, at		60	per Howitzer.
		8	Ditto	75	ditto
		24-Pounders,		95	ditto
	Spherical.	8-Inch, at		300	per Howitzer.
		24-Pounders,		350	ditto

Light balls, in the proportion of 10 for each 8-Inch, and 15 for each 24-pounder howitzer.

MORTAR.

Shells	10-Inch, at	500	per	Mortar.
	8 ditto	600		ditto
	$5\frac{1}{2}$ ditto	400		ditto
	$4\frac{2}{5}$ ditto	400		ditto
Pound Shot	10-Inch, at	500	per	Mortar.
	8 ditto	600		ditto
	$5\frac{1}{2}$ ditto	300		ditto
	$4\frac{2}{5}$ ditto	300		ditto

Light balls, in the proportion of 5 for each 8-Inch, and 10 for each of the small mortars.

Each round of pound-shot consists of 100 shot for the 10 and 8-inch mortars, and of half that number for the $5\frac{1}{2}$ and $4\frac{2}{5}$ inch.

OF THE ARRANGEMENT OF THE ARTILLERY DURING A SIEGE.

The instant it is ascertained that the enemy's troops are in motion towards the place, the barbette batteries must be established in the flanked angles of the bastions and ravelins, and a proportion of the light guns and 24-pounder howitzers, mounted on travelling carriages, must be placed in the out-works and covered-way.

The following is the arrangement usually made for the reception of the investing corps, when it is not known upon what point they may commence operations.

Three guns on the barbette of each bastion,—one 24, and two 18-pounders, and three 9-pounders on the barbette of each of the ravelins. In the saliant

places of arms of the bastions, one 24-pounder howitzer; and in those of the ravelins, two 6-pounders.

The heavy mortars should be placed one in each bastion, and the remainder of the ordnance in reserve, behind the curtains, in readiness to move on whichever side it may be required.

By this arrangement the whole of the barbette guns, and the guns and howitzers in the out-works, will be in readiness to act in any direction, till the side of attack is determined on; and, with the addition of the reserve, thirty-five pieces of ordnance may be opened against the enemy the very first night he begins to work upon the trenches. In the first moments of the investment, however, the artillery of the place should not endeavour, by an useless expenditure of ammunition, to disturb the besiegers in their operations; it is only when they are making permanent dispositions for their establishment, that the fire of the place should be opened upon them.

The day succeeding the night on which the trenches are opened, and the side of attack determined, a new arrangement of the artillery of the place must be made as follows:—

All the 24 and 18-pounders must be removed to the front attacked, and the other batteries, if necessary, supplied with 12-pounders. The barbettes of the bastions on this front may have each five guns,—three 24 and two 18-pounders,—and the remaining 18-pounders may be arranged behind the curtains,—two

towards each of the extremities of the front curtain, and two at the furthest extremity of each of the collateral curtains. The howitzers, in reserve, should be placed, two in each of the saliant angles of the covered-way of the bastions of this front, and two in each of those of the collateral bastions, which, with those already there, must fire *en ricochet* down the prolongations of the capitals. There should, also, be three 6-pounders in the saliant place of arms of the ravelin of the front attacked, and also three in each of those of the two collateral ravelins, to fire over the palisading; and, lastly, there should be five 9-pounders on the barbette of the front ravelin.

This arrangement will bring fifty-two guns and howitzers, and four mortars to fire on the approaches after the first night; and, with a few variations, this will be the disposition of the artillery of the place, till the besiegers' first batteries are ready to open. The instant they begin to work upon these batteries, all the fire of the place must be directed to those points, and the mortars, which had previously fired at low angles, must now fire with greater elevation, but at all times sparingly.

As soon as the enemy's batteries are fairly established, the guns *en barbette* must be covered by merlons, and the embrasures should be occasionally masked. Whilst this work is carrying on, the situations of the guns should be changed, and new directions given to them; as by frequently practising this

manœuvre, the enemy will also be obliged to change his dispositions of attack, and time will thereby be gained by the besieged.

As the enemy approaches towards the second parallel, the fire of the place must be spread over all parts of his line of operations, and with a view of contributing to this object, the royal and Cœhorn mortars should be ranged in the places of arms and branches of the covered-way. When the approaches are carried on from the second parallel, and the enemy is about to establish the demi-places of arms, the fire of the place must be concentrated on the debouchés from the parallel, and multiplied with all possible activity.

In proportion as the besieger pushes forward his approaches to the third parallel, the artillery must be withdrawn from the covered-way to the ravelins, or to the ditch, if dry, or to other favourable situations; and by degrees, as the enemy advances, to the body of the place. During this period of the siege, the embrasures must be prepared in the flanks, the curtain which joins them, and in those parts of the faces of the bastions which command the ditch of the front ravelin. All these embrasures must be ready to open, and the heavy artillery mounted in them, the moment the enemy attempts a lodgment on the glacis.

We have now arrived at the crisis of the siege, and every effort should be made to take advantage of this favourable moment, when the enemy, by his own works, must mask his former batteries, and before he is able to open his new ones.

AXLE-TREES.

There are two kinds of axle-trees, viz. wood and iron. The former are for garrison and ship carriages; the latter for field, travelling, and transporting carriages.

I.—Garrison and Ship Carriages.

Nature of Carriages.	Fore Axle-tree						Hind Axle-tree.					
	Arms.		Depth.	Breadth.	Length.		Arms.		Depth.	Breadth.	Length.	
	Length.	Diameter.			Between the Shoulders	Total.	Length.	Diameter.			Between the Shoulders	Total.
	In.	In.	In.	In.	Ft. In.	Ft. In.	In.	In.	In	In.	Ft. In.	Ft. In.
Garrison. Guns. 42-Pounder	10·75	7·5	7·75	11·0	—	4 11·0	10·75	7·5	12	7·75	—	4 11·0
32-Do.	10·75	7·5	7·75	11·0	—	4 10·0	10·75	7·5	12	7·75	—	4 10·0
24-Do.	9·75	6·5	6·75	10·5	—	4 6·5	9·75	6·5	12	6·75	—	4 6·5
18-Do.	9·5	6·5	6·75	10·5	—	4 5·0	9·5	6·5	12	6·75	—	4 5·0
12-Do.	9·5	6·5	6·75	10·5	—	4 1·0	9·5	6·5	12	6·75	—	4 1·0
9-Do.	9·5	6·5	6·75	10·5	—	4 —	9 5	6·5	12	6·75	—	4 —
6-Do.	9·0	5·5	5 75	9·5	—	3 10·0	9·0	5·5	12	5·75	—	3 10·0
Garrison. Guns 4-Do.	9·0	5·5	5·75	6·5	—	3 4·0	9·0	5·5	11	5·75	—	3 4·0
3-Do.	9·0	5·5	5·75	6·5	—	3 4·0	9·0	5·5	11	5·75	—	3 4·0
How. 10-Inch			7·75	10·0		4 9·5	—	—	12	6·0		3 —
8-Do.			7·75	9·5		4 9·0	—	—	12	5·5		2 7
Carron. 68-Pounder			10·75	7·75		4 5·0	—	—	—	—	—	— —
24-Do.			10·0	8·0		4 2·0	—	—	—	—	—	— —
18-Do.			9·0	7·0		3 7·5	—	—	—	—	—	— —
12-Do.			9·25	6·75		3 3·0	—	—	—	—	—	— —
Ship. 68-Pounder		6·25	7·75	7·25		3 2·0	10·5	6·25	12	6·5	2 11·0	4 8·0
32-Do. 9 ft. 6 in.	10·5	6·25	9·25	6·5	3 1	4 10·0	10·5	6·25	12	6·5	3 1	4 10·0
32-Do. 8 ft.	10·0	6·25	9·0	6·5	3 4·5	4 2·5	10·0	6·25	12	6·5	3 9	4 7·0
24-Do. 9 ft. 6 in. / 9 ft. or 7 ft. 6 in.	10·0	6·25	9·0	6·5	2 11	4 7·0	10·0	6·25	12	6·5	2 11	4 7·0
24-Do. 6 ft. or 6 ft. 6 in.	9·5	5·75	9 0	6·0	2 9·5	4 4·5	9·5	5·75	11	6·0	2 9·5	4 4·5
18-Do. 9 ft. or 8 ft.	9·5	5·75	8·5	6·0	2 9·5	4 4·5	9·5	5·75	12	6·0	2 9·5	4 4·5
18-Do. 6 ft.	9·5	5·25	8·5	5·5	2 6·0	4 1·0	9·5	5·25	11	5·5	2 6·0	4 1·0
12-Do.	8·5	5·25	8·0	5·5	2 5·5	3 10·5	8·5	5·25	12	5·5	2 5·5	3 10·5
9-Do.	8·0	5·0	7·75	5·25	2 3·5	3 7·5	8·05	5·0	12	5·25	2 3·5	3 7·5
6-Do.	7·25	4·5	7·5	4·75	2 2·0	3 4·5	7·2	4·5	12	4·75	2 2·0	3 4·5
4-Do.	7·0	3·75	6·5	4·0	2 —	3 2·0	7·0	3·75	10	4·0	2 —	3 2·0
3-Do.	6·5	3·5	6·5	3·75	1 10·0	2 11·0	6·5	3·5	8	3·75	1 10 0	2 11·0

E

II.—Field, Travelling, and Transporting Carriages.

	Nature of Axle-trees.	Length of Bed between the Shoulders. Ft.	In.	Arms. Length of Box. In.	Length of Arm. In.	Thickness of Washer. In.	Width of Linch-hole. In.	Diameter. Shoulder. In.	Diameter. Linch. In.	Total length from Point to Point. Ft.	In.	Weight including Linchpins and Washers. cw.	qr.	lb.
Axle-trees.	24-Pr. Gun, or 10-Inch How.	3	1·5	18	20·503	·625	·875	3·75	2·75	6	6·5	1	3	8
	8-Inch Howitzer, or 18 and 12-Pounder Iron Guns	3	3	16	18·503	·625	·875	3·5	2·5	6	4	1	1	18
	Limbers for the above	3	4	14	16·503	1·0	·75	3 13	2·13	6	1·5	1	—	2
	Devil Carriages, Large	4	2·25	16	18·503	·625	·875	3·5	2·5	7	3·25	1	2	15
	Devil Carriages, Limber	4	8	14	16·503	1·0	·75	3·13	2·13	7	5·5	1	2	4
	Devil Carriages, Small	3	8	14	16·503	1·0	·75	3·13	2·13	6	5·5	1	—	14
	Medium 12-Prs. and Limbers; Guns: 12-Pounder, Light; 9-Ditto; 6-Ditto, Heavy; Howitzers: 24-Pounder; 5½-Inch	3	7	14	15·875	1·0	·75	3·13	2·13	6	4·5	1	—	2
	Sling Cart	3	8	16	15·875	·625	·75	3·5	2·5	6	9	1	3	—
Arms.	Platform Waggon	3	8	14	16·75	1·0	·75	3·13	2·13	6	5·5	1	..	3
	Guns: 6-Pounder, Light; 3-Ditto, Heavy; Howitzers, 12-Pounder; Limbers, 6-Pounders, Light; Bodies: Am. Limb Carriages, Store do. do., Forge Waggons; Carts: Baggage, Cavalry Forge, Musquet Ball	3	8	13	15·625	1·0	·625	2·75	1·75	6	3·25	—	3	12
	Carts, Trench	3	—	13	15·25	·625	·625	2·75	1·75	5	6·5	—	2	12
	Wag., Small Arm Ammunit.	3	8	13	15·625	1·0	·625	2·75	1·75	6	3·25	—	3	12
	Wag., Flanders; Baggage; Pontoon Carriages	3	8	13	15·25	·625	·625	2·75	1·75	6	2·5	—	2	12
Axle-trees.	Travelling Carriage, and Limber 6-Pr. for Mountain Service	2	8	13	14·625	1·0	·625	2·75	1·75	5	3·25	—	2	22
	Carriage, and Limber 3-Pr. Light, $4\frac{2}{5}$-In. Howitzer Do. and Limber Cart	2	6·5	11	12·75	·5	·5	2·0	1·5	4	8	1 (with Hand Cart)		8
	Hand Cart	3	2	11	12·75	·5	·5	2·0	1·5	5	3·5	1 (with above)		8
	Mountain Service, 3 and 1 Pounders, and $4\frac{2}{5}$-Inch Howitzers	1	4·25	9	10·5	·375	·375	1·5	1·125	3	1·25	—	—	20

BALLS.

These are of three descriptions, viz.—lead, light, and smoke-balls. The following are the weights, dimensions, &c. of each.

I.—Of Lead Balls.

General Table of Lead Balls for Small Arms.

Nature of Ball.	Calibre.	Number				Number made from One Ton of Lead.
		In a Pound.		In a Cwt.		
	In.	Service	Proof.	Service	Proof.	
Musquet	·68	$14\frac{1}{2}$	11	1624	1332	32480
Carbine, Common	·60	20	17	2240	1904	44800
Carbine, Musq. Bore	·68	$14\frac{1}{2}$	11	1624	1332	32480
Rifle	·60	20	17	2240	1904	44800
Pistol, Musq. Bore	·68	$14\frac{1}{2}$	11	1624	1332	32480
Pistol, Carb. do.	·60	20	17	2240	1904	44800

In casting the balls, the only points requiring particular attention are, first,—that the lead be not raised to too high a degree of heat, but only to such a state of fluidity as will allow of its running freely into the moulds; and, secondly,—that the moulds be dipped in water after every dozen casts to cool them. Should these precautions be omitted, the balls will not be solid.

The weight and dimensions of lead balls may be computed by means of their specific gravities, but still more readily by the following rules.

1. *To find the Diameter of a Ball, its Weight being known.*

Multiply the given weight, in pounds, by 9, and the cube root of half the product will be the diameter, in inches.

Example. The weight of a ball being 2 pounds, required its diameter?

Here, $\sqrt[3]{\frac{2+9}{2}} = \sqrt[3]{9} = 2\cdot080084$ inches. The diameter sought.

2. *To find the Weight of a Ball, its Diameter being known.*

A ball of 4·5 inches diameter weighs 17 pounds; therefore, say:—

As the cube of 4·5 or 91·125 inches,
Is to 17 pounds;
So is the cube of the diameter of any other ball,
To its weight.

Example. The diameter of a ball being 6·6 inches, required its weight?

Here, 91·125 : 17 :: 287·496 : 53·6343lbs. The weight sought.

II.—Of Light-Balls.

Light-balls are of two descriptions, viz.—spherical and oblong. The cases for the spherical are made of

paper, and are precisely the same in every respect as those for smoke-balls; but the oblong cases, or rather the skeletons upon which they are formed, consist of two hollow iron hemispheres, connected together longitudinally, about the circumferences of their bases, by means of four iron bars of about an inch in breadth, two-tenths of an inch thick, and in length equal to about a calibre and a half of the piece of ordnance for which they are intended. The cylindrical parts of these skeletons are then covered with canvas, and, after the balls are filled with composition, are firmly woulded round with strong line:—each ball, when completed, forming a cylinder, terminated by two hemispheres.

Composition.

Saltpetre, 6 pounds, 5 ounces; sulphur, 2 pounds, 8 ounces; rosin, 1 pound, 14 ounces; and linseed oil, 7 ounces, 8 drachms.

The dry parts of the above proportion of ingredients must, previously to being mixed, be pulverized; and then thoroughly incorporated by rubbing them between the hands, and afterwards passing them three or four times through a hair sieve. The oil is next boiled, and the dry ingredients added to it, in small quantities at a time, stirring it all the time of putting in till the whole proportion is mixed. In about a quarter of an hour the composition is generally ready for use.

The following are the Proportions of Materials required for making Ten Oblong Light-Balls of each Nature.

DESCRIPTION OF MATERIALS.	Nature of Balls.			
	10-In.	8-In.	$5\frac{1}{2}$-In.	$4\frac{2}{5}$-In.
Carcasses, Oblong.........	10	10	10	10
Saltpetre, Ground, lbs. ozs.	203 10	189 15	38 13	19 5
Sulphur, ... ditto	18 2	75 11	18 1	7 11
Rosin,............ ditto	60 0	56 4	11 7	5 10
Powder, Mealed, ...ditto	3 2	1 14	0 8	0 8
Oil, Linseed, Raw, Gallons, Quarts, Pints ..	2 0 0	1 3 1	0 1 $1\frac{1}{2}$	0 0 $1\frac{3}{4}$
Kitt, ... lbs. ozs.	8 0	4 0	2 0	1 8
Match, ... ditto	0 5	0 $\frac{3}{4}$	0 2	0 $1\frac{1}{2}$
Line { 18-Pounder, ..ditto	15 0			
Line { 12-ditto, ... ditto		10 10		
Line { 3-ditto, ... ditto			3 12	3 0
Twine, Packing .... ditto	0 10	0 8	0 4	0 2
Canvas, .. yards	17 0	7 0		
Hessian, ditto..........	$1\frac{1}{4}$	1	$\frac{3}{4}$	$\frac{1}{2}$
Osnaburg, ditto..........			5	3

The following observations on light-balls are extracted from Colonel Jones's truly valuable journal of the siege of Cuidad Rodrigo :—

" Light-balls are of such excellent use in discovering working parties, that surely some means ought to be taken to render them of dangerous approach, by attaching (to them) a grenade or other missile so prepared as to explode at uncertain periods of their burning.

" At these sieges, two or three bold men of the

engineers' brigade were always in readiness to run up and extinguish the light-balls as they fell, and generally succeeded, in a few seconds, in smothering them, with filled sand-bags, or by shovelling earth over them.

"The garrison always directed their fire on the men whilst so occupied, which diverted it altogether from the working party, employed perhaps at a few yards distance from the ball, to its right or left. Some casualties occurred to the men thus employed, but generally they had extinguished the light-ball before a second discharge of artillery could be brought upon them."

III.—Of Smoke-Balls.

Dimensions of Smoke-Ball Cases.

Nature of Ball.	Diameter.		Thickness of Case.	Diameter of Fuze-hole.	
	Interior.	Exterior.		Exterior.	Interior.
	Inches.	Inches.	Inches.	Inches.	Inches.
10-Inch	8·6	9·75	1·15	1·57	1·45
8-ditto	6·65	7·75	1·1	1·325	1·227
5½-ditto	4·75	5·54	·79	·894	·826
4⅖-ditto	3.75	4·4	·65	·832	·769

Composition.

Saltpetre, 1 pound; corned powder, 5 pounds;

sea-coal, 1 pound, 8 ounces; Swedish pitch, 2 pounds; and tallow, 8 ounces.

In mixing these ingredients, the following directions must be attended to:—

1. The corned powder should be spread upon a table and bruised, and the saltpetre sifted over it; these two ingredients should then be incorporated by rubbing them between the hands for a few seconds, and again spread upon the table.

2. The sea-coal is next to be sifted over the saltpetre and corned powder, and incorporated with them in same manner.

3. The pitch and tallow are then to be melted and raised to a considerable degree of heat, when the dry parts of the composition are to be added, in small quantities at a time, stirring the liquid all the time of putting in.

In filling the cases, the following dry composition is introduced in three portions as follows:—one portion when the case is one quarter filled, a second portion when it is half filled, and the remaining portion when it is three-quarters filled.

Dry Composition.

Sulphur .... 1 ounce Sea-coal.... 1 ditto	For the 10 and 8-inch.
Sulphur.. 8 drachms Sea-coal.. 8 ditto....	For the $5\frac{1}{2}$ and $4\frac{2}{5}$-inch.

The following are the Proportions of Materials required for making Ten Smoke-Balls of each Nature.

DESCRIPTION OF MATERIALS.	Nature of Balls.							
	10-In.		8-In.		$5\frac{1}{2}$-In.		$4\frac{2}{5}$-Inch	
Saltpetre, pulverized, lb oz.	17	4	10	0	7	0	4	0
Sulphur, ground .... ditto	2	2	1	4	1	0	0	12
Powder, corned .... ditto	85	0	50	0	35	0	20	0
Tallow, ... ditto	9	12	5	0	3	8	2	0
Match, ... ditto	0	1	0	$0\frac{3}{4}$	0	$0\frac{1}{2}$	0	$0\frac{1}{2}$
Sea-Coal, pounded,.. ditto	27	10	16	4	11	6	6	8
Pitch, ... ditto	34	0	20	0	14	0	8	0
Paper, Cartridge, 24-Pounder } qrs. shts.	6	20	2	12	1	12	0	17

BARRELS.

The following Table contains the Weight and Dimensions of Powder Barrels, Filled and Empty.

DESCRIPTION OF BARREL.		Dimensions.				Weight.	
		Depth.	Diameter.			Empty.	Filled.
			Top.	Bulge.	Bottom.		
		Ft In	Ft In	Ft. In.	Ft In	lb. oz	lb. oz.
Water-Tight		1 9	1 3	1 5·5	1 3	35 4	115 4
Whole	Copper Hooped	1 9·6	1 3·6	1 5·3	1 3·5	27 0	117 0
	Hazle do..	1 9·6	1 3·6	1 5·3	1 3·5	18 4	108 4
Half ..	Copper do..	1 5·3	1 0·3	1 2·0	1 0·3	17 4	62 4
	Hazle do..	1 5·3	1 0·3	1 2·0	1 0·3	11 8	56 8
Quarter	Copper do..	1 1·2	0 9·3	0 10·7	0 9·4	10 8	33 0
	Hazle do..	1 1·2	0 9·3	0 10·7	0 9·4	7 10	30 0

The water-tight barrels contain 80 pounds of powder. The whole barrels are made to contain 100, the half-barrels 50, and the quarter-barrels 25 pounds of powder each; but of late, only nine-tenths of these quantities have been put into them; thereby leaving room for the powder to be shifted which tends very much to its preservation when in store.

BUDGE BARRELS.

These barrels are employed in the service of batteries, and have leather covers drawing together like the mouth of a bag. They are of two descriptions, copper and hazle hooped.

Dimensions.	*Weight.*
Length .. 0 feet, 10·5 inches.	Copper-hooped, 10lbs. filled, 48 lbs.
Diameter, 1 foot, 1·0 inches.	Hazle-hooped, 6 lbs. filled, 44lbs.

BASKETS.

Ballast baskets contain half a bushel.

Dimensions.	*Weight.*
Diameter, 1 foot, 6 inches.	5 pounds.
Depth, 1 foot, 0 inch.	

BATTERY.

GENERAL DIMENSIONS OF BATTERIES.

I.—Of Gun Batteries.

The length of the epaulement depends, of course,

upon the number of guns which the battery is to contain:—about 18 feet are usually allowed for each gun.

Dimensions of the Profile and Embrazures.

			Ft.	In.
Epaulement.	Height	Interior	7	0
		Exterior	6	4
	Thickness	Top	18	0
		Bottom	25	0
	Slopes	Interior	2	0
		Exterior	5	0
Berm		Breadth	3	0
Ditch	Slopes	Interior	4	0
		Exterior	5	0
	Depth		8	0
	Breadth	Top	17	6
		Bottom	8	6
Embrazures.	Openings	Interior	1	8
		Exterior	9	0
	Soles	Height	2	8
		Slope	1	6

These dimensions are calculated for the worst descriptions of soil, and give, after deducting the embrazures, about 2157 cubic feet of earth for each gun in the battery.

In earth of greater tenacity, or in confined situations, the following dimensions may be adopted.

Length of the epaulement, 15 feet per gun.

Profile and Embrazures.

			Ft.	In.
Epaulement.	Height	Interior	7	0
		Exterior	6	4
	Thickness	Top	15	0
		Bottom	20	0
	Slopes	Interior	2	0
		Exterior	3	0

Berm		Breadth	2	0
Ditch	Slopes	Interior	3	0
		Exterior	4	0
	Depth		8	0
	Breadth	Top	14	10
		Bottom	7	0
Embrazures.	Openings	Interior	1	8
		Exterior	7	6
	Soles	Height	2	8
		Slope	1	4

In these reduced dimensions, the quantity of earth for each gun will be, after deducting the embrazure, about 1457 cubic feet.

II.—Of Howitzer Batteries.

Howitzer batteries, with the exception of the embrazures, have precisely the same dimensions as those for guns. The interior openings of the embrazures are made 2 feet 6 inches wide, and the soles are counter-sloped inwards at an angle of about 10 degrees.

III—Of Mortar Batteries.

The profile, excepting that of the ditch, of these batteries corresponds in every respect with those above-mentioned for guns and howitzers.

Mortar batteries, having no embrazures, require an additional quantity of earth for the formation of their epaulements. To obtain this additional quantity, therefore, 2 feet must be added to the breadths of the ditch, over and above the dimensions established for gun or howitzer batteries having embrazures.

The mortars being supposed to be placed at the same distances apart as the guns and howitzers, these dimensions will give for the first profile 2457 cubic feet of earth for each mortar, and for the second profile 1738 cubic feet per mortar.

The mortars should be placed at the following distances from the foot of the interior slope of the epaulement, according to the angles at which they are to be fired.

At 10 feet	for firing at	45 degrees
12	.... at	35
14	.... at	30
17	.... at	25
19	.... at	20
30	.... at	15
56	.... at	10
80	.... at	5

If the situation of the battery will admit of its being sunk, so that the soles of the embrazures may coincide with the level of the ground, a great advantage will be gained, and considerable time and labour saved in their construction.

In batteries without embrazures, this method may almost always be adopted; and in some situations it becomes absolutely necessary, in order to obtain sufficient earth for the epaulements; for when a battery, for example, is to be formed on the crest of the glaces,

or on the counterscarpe, there can be no excavation except to the rear.

IV.—Of Barbette Batteries.

When the guns are not to act against particular points; when the enemy can attack in any direction, or when the battery is situated on higher ground than any which he can possibly occupy, so that the greater part of his shot must pass above it; in these cases the guns should be fired en-barbette, that is to say, over the epaulement. To enable the guns thus to act, mounds of earth must be raised in rear of the epaulement to a height just sufficient to allow the muzzles of the guns to be run over its crest; or, when the battery is to be sunk, these mounds should be marked out previously to breaking ground, and the earth forming the barbette left undisturbed.

V.—Of Coast Batteries.

Coast batteries generally consist of a simple epaulement, without much attention being paid to the dimensions of the ditch. They are sometimes, however, made with embrazures like a common gun or howitzer battery; but more generally the guns are mounted on *traversing platforms*, and, in that case, fire over the epaulement.

In general, military writers prefer low situations for these batteries; but M. de Gribauvale lays down some principles upon this subject for placing the battery in

such security as to enable it to produce its greatest effect. He says that the height of a battery of this kind above the level of the sea must depend upon the distance of the principal objects which it has to protect or annoy. The shot, to ricochet with effect, should strike the water at an angle of about 4 or 5 degrees, at the distance of 200 yards. Therefore the distance of the object must be the radius, and the height of the battery the tangent of this angle of 4 or 5 degrees, which, at the above distance, will be about 14 yards.

Durtubie estimates that a battery of 4 or 5 guns, or a martello tower, well posted, will be a match for a first-rate man of war.

Remarks on Batteries in General.

The dimensions laid down in the preceding pages are founded upon the supposition, that the battery, and the point against which it is to be erected, are in the same horizontal plane; but though this may be assumed as the most common case, and the general rule, there are, of course, two contingencies, varying from it:—

1. *When the battery is situated in a plane above the object.*

2. *When the object is situated in a plane above the battery.*

Each of these conditions requires that the height of the epaulement, and consequently the dimensions of the

ditch, should be diminished or increased according to the following principles.

When the Battery Commands the Object.

In this case it is manifest that the height of the epaulement need not be so great as when the battery and object are situated in the same horizontal plane; for the line of fire from the lower situation can never approach nearer to the heads of the men in the battery than the interior height of the epaulement, which may therefore be lowered in proportion as the command of the battery increases, provided it never be less than 6 feet.

When the Object Commands the Battery.

Here the line of fire approaches, at every instant, nearer and nearer to the head of a man stationed behind the epaulement; and in the same proportion in which the command of the object increases, will the distance from the foot of the epaulement diminish, at which a shot from the enemy will strike the terreplein. In this case, therefore, it is evident that the height of the epaulement must be increased, directly, in proportion to the command of the object, and, inversely, in proportion to its horizontal distance from the battery.

To Determine the Proper Height to be given to an Epaulement.

Before the height of the epaulement can be deter-

mined, it is necessary to know the horizontal distance between the object and the battery, and the distance in rear of the latter at which it is intended that a man should be protected from the enemy's fire. These two points being ascertained, the proper height may be determined by a simple calculation, or practically by the following easy process.

Having traced out upon the ground the horizontal breadths of the several slopes of the epaulement, a man must place himself upon the line over which the crest is supposed to pass, and there erect a long staff; at the same time a second man, provided with another staff 6 feet long, should place himself in line with the former and the object, and as far in rear of the intended crest as it is desired that the ground should be defiladed or placed under cover from the enemy's fire,—and there erect his staff. Then, by placing his eye on a level with the top of it, he will observe where the line of sight, passing over the hostile object, cuts the first staff, and the point of intersection thus obtained will mark the height to be given to the epaulement.

To Determine the Dimensions of the Ditch.

The profile of the epaulement being known, and the materials for its construction remaining to be procured from the excavation of the ditch, it follows that the solid contents of the one of them must be just equal to that of the other. Therefore, as the extreme

depth of the ditch is fixed at 8 feet, on account of the difficulty of raising the earth to a greater height, the breadth will be found by the following rule:—

Divide the superficial content of a vertical section of the epaulement by the proposed depth of the ditch, and the quotient will be the mean breadth.

Then, if half the sum of the horizontal breadths of the two slopes be added to this mean breadth, the sum will be the breadth at top; and if half the sum of these breadths be subtracted, the difference will be the breadth at bottom.

Example. The superficial content of the vertical section of an epaulement being 144 square feet, the proposed depth of the ditch 8 feet, and the horizontal breadths of its two slopes 4 and 5 feet respectively, required its breadth at top and bottom?

Here, $144 \div 8 = 18$ feet. The mean breadth.

And, $\frac{4+5}{2} = 4$ feet 6 inches. Half the sum of the slopes.

Therefore, $18 + 4..6 = 22$ feet, 6 inches. The breadth at top.

And, $18 - 4..6 = 13$ feet, 6 inches. The breadth at bottom.

For the time necessary to construct any work, distribution of workmen, &c. see the word FORTIFICATION.

BLUE LIGHTS.

These lights are fixed in hand-cases, of well seasoned alder, of nearly similar dimensions to a 10-inch fuze, except that the cups are rather more capacious.

Composition.

	lbs.	oz.
Saltpetre	7	0
Sulphur	1	12
Red Orpiment	0	8

The ingredients are first pulverized, and then, after rubbing them between the hands for a few minutes, passed four times through a fine hair sieve.

The brilliancy of the light depends upon the purity and thorough incorporation of the several parts of the composition.

The following proportions of materials are required to complete one hundred lights:—

	lbs.	ozs.	drs.
Saltpetre	9	10	0
Sulphur	2	6	8
Red Orpiment	0	11	0
Thread { Pack	0	4	0
Thread { Dutch	0	1	0
Quick-match	0	1	8
Paste	2	0	0

Paper { Small-Arm packing, sheets	18
Paper { 24-Pounder common cartridge, ditto	10½
Paper { Brown ditto	17
Timber, alder poles, 2·75-Inches in diameter, feet running	60

BOMB VESSELS.

The invention of bomb-vessels is due to our ingenious neighbours the French, who first employed them in 1681, at the bombardment of Algiers. The earliest mention of them in the English service bears the date of 1688, but upon what occasion they were employed, we have not been able to ascertain.

It is only of late years that these vessels have attained to their present state of perfection. Upon the old establishment, they carried two 10-inch mortars, four 68, and six 18-pounder carronades, and were accompanied by a tender, generally a brig, on board of which it was usual to place a portion of the stores, and to embark the artillery-men till their services were required on board the bomb-vessel. This absurd practice is now, however, abolished, and for obvious reasons; suffice it to mention, the inconvenience attendant on the accidental separation of the two vessels at sea,—a not unusual occurrence in rough weather—whereby both became useless.

The modern bomb-vessels carry one 13 and one 10-inch mortar, two long 6-pounders, one 12, and eight 24-pounder carronades. Their burthen is about three-hundred and fifty tons, and the complement of men sixty-seven, with the usual establishment of officers for ships of the same class, viz.—a commander, two lieutenants, a master, surgeon, and purser

The detachment of marine artillery for the service of the mortars, consists of a lieutenant, serjeant, corporal, bombardier, and ten gunners.

PROPORTION OF ORDNANCE, AMMUNITION, AND STORES FOR A BOMB-VESSEL CARRYING ONE 13, AND ONE 10-INCH MORTAR, TWO LONG 6-POUNDERS, ONE 12, AND EIGHT 24-POUNDER CARRONADES.

Ordnance, Carriages, and Stores.

Mortars		13 Inch	1
		10 ditto	1
Guns		6-Pounders	2
Carronades		24 ditto	8
		12 ditto	1
Mortar Beds		13-Inch	1
		10 ditto	1
Carriages	Guns	6-Pounders	2
	Carronades	24 ditto	8
		12 ditto	1
Pintails for the Mortars			2
Elevating Screws Carronade		24-Pounders	8
		12 ditto	1
Traversing Bars		24 ditto	8
		12 ditto	1
Hand-spikes	Mortar		6
	Common		4
Linstocks, Common			4
Powder Measures, Full Charge		6-Pounders	1
Marline-spikes			3

Wadhooks with Rammers.	Gun	6-Pounder	1
	Carronade	24 ditto	1
		12 ditto	1
Sponges	Mortar	13-Inch	2
		10 ditto	2
	Gun, 6-Pounder	Common	1
		Rope	2
	Carrronade	24-Pounder	8
		12 ditto	1
Heads and Rammers.	Gun	6-Pr. Rope	1
	Carronade	24 ditto	2
		12 ditto	1
Sponge Caps	Gun	6-Pounder	3
	Carronade	24 ditto	8
		12 ditto	1
Mallets			4
Steel Purchase Chisels			4
Whiting, lbs.			28
Budge-Barrels			2
Tompions	Gun	6-Pounder	8
	Carronade	24 ditto	32
		12 ditto	4
Slow-match, cwts.			1
Powder-horns			18
Priming-irons, sets			36
Magazine	Slippers, sets		2
	Brooms	Long	
		Short	1
Sheep Skins			
Tallow, qrs.			1
Melting Ladles			1
Copper	Funnels		1
	Shovels		1

Copper	Canhooks, pairs	2
	Adzes	2
	Drivers	4
	Vices	2
	Snuffers, pairs	2
Vent-Bits		5
Hand-Screws	Long	1
	Short	1
Iron Crows, 4 feet, 6 inches long		4
Linchpins, pairs		1
Lanthorns	Muscovy	2
	Tin	1
	Dark	2
Baskets		4
Twine, lbs		4
Junk, cwts.		15
Hand crow Levers	6 feet long	4
	3 ditto	4
Nails	Twenty-penny	100
	Ten-penny	200
	Six-penny	300
Forelock Keys, Copper, pairs		3
Tackles and Blocks	$2\frac{1}{2}$-Inch	4
	2 ditto	6
Marline-skeins		12
Pails, Iron-hooped		4
Rope	White, 3-inch fathoms	40
	Tarred, 2 ditto	40
Blocks, single, pairs		4
Tackle Hooks, pairs	Large	11
	Small	4
Musquets, Black		40

Bayonets			40
Musquetoons, Iron			2
Pistols, Ribbed, pairs			16
Boxes	Cartouch		40
	Cartridge	Musquet	1
		Pistol	1
	Tube		4
Sweet Oil, gallons			3
Pole Axes			6
Swords			40
Pikes			40
Drums, Complete			1
Brass Locks	Gun		2
	Mortar		2
	Carronade		9
Turn Screws for Carronades			13
Wooden Cartouches.	Guns, 6-Pounders		5
	Carronades	24 ditto	20
		12 ditto	2
Lead	Aprons		13
	Lock Covers		11
Flints	Musquet		500
	Pistol		150
	Carronade		100
Breechings	Gun	$4\frac{2}{5}$-Inch	3
	Carronade	$6\frac{1}{2}$ ditto	12
		$5\frac{1}{2}$ ditto	2
Tackles	2-Inch		24
	$1\frac{1}{2}$ ditto		3
Wad Gauges	Gun	6-Pounder	1
	Carronade	24 ditto	2
		12 ditto	1

Armourer's Tools.

Vices	Standing	1
	Hand	1
Wrenches		1
Stakes, Poize, 4lbs.		1
Punches and Cold Chisels		8
Braces, Iron		1
Hammers	Hand	1
	Small	1
Square Bits		1
Screw Plates, with 7 Taps		1
Drill	Bows	1
	Boxes	1
	Slings	2
Drills of Sorts		6
Breast Pieces		1
Rubbers, Poize, 3lbs.		1
Files	Hand	1
	Bastard	2
	12-Penny, Smooth	1
	9 ditto ditto	1
	6 ditto ditto	1
	3 ditto ditto	1
	6-Penny Rough	6
	2 ditto ditto	8
	Slitting	1
File Handles		18
Emery, lbs.	Fine	1
	Coarse	1
Burnishers		1
Wiping Rods	Musquet	1
	Pistol	1

Forge Tongs, pairs			1
Nails	Lock		60
	Side		20
	Breech		15
Spring Hooks			1
Tool Chests			1

Spare Articles.

Pintail		1
Cap-squares		2
Washers		4
Keys and Chains		4
Bolts	Traversing	4
	Dog	4
Wedges and Blocks, sets		1
Eye-pins and chains		2
Axle-trees, Hind		1
Trucks, Fore, pairs		1
Stool-Beds		1
Staves for Wadhooks and Ladles		2
Combs for Sponges		2
Quoins	Gun	1
	Mortar	2
	Carronade	8

Ammunition and Laboratory Stores.

Shells	Common	13-Inch	400
		10 ditto	400
	Hand, Fixed		150
Carcasses, Fixed		13-Inch	40
		10 ditto	40
Portfires			200

Tubes	Tin		440
	Quill		440
Fuze-composition, lbs.			158
Cartridge Paper, 6-Pounder, quires			10
Powder-Bags			6
Rasps, ½ round			6
Cotton-wick, lbs.			4
Brushes	Glue		4
	Kitt		6
Glue Kettles, Iron			2
Rag-stones			2
Diagonal Scales			1
Compasses, pairs			2
Spoke Shaves			1
Sash Saws			4
Files, 3-square			8
Saw Setters			1
Funnels	Copper	13-Inch	1
		10 ditto	1
	Tin for Loading		2
Mallets	13-Inch		14
	10 ditto		14
Fuze Engines			1
Line 18-Pounder, lbs.			2
Canvas, yards			62
Flax, lbs.			5
Glue, ditto			5
Salting Boxes, Copper			2
Pincers, pairs	Fuze		3
	Common		3

Augers, common			2
Cutting Knives			4
Scissars, pairs			2
Needles			24
Quadrants			1
WoodenDrifts	13-Inch		2
	10 ditto		2
Thread, lb.	Common		1
	Pack		6
Claw Hammers			2
Plummets, Lead			3
Mealed Powder, lbs.			90
Soft Soap, ditto			64
Tallow, ditto			56
Kitt, ditto			80
Kitt Kettles			1
Trivets for ditto			1
Hooks, pairs	Hand		3
	With Thimbles		3
	Beam		2
	Can		2
Charcoal, bushels			6
Quick-match, lbs			20
Spirits of Wine, gallons			8
Rammers for Mortars			2
Corkscrews			2
Cartridges, uncured, 32-Pounder			24
Valenciennes-composition, Proportions		13-Inch	300
		10 ditto	300
Fuze Blocks with 1, 13-Inch, and 1, 10-Inch Socket			2

Fuze Drifts	13 Inch	4
	10 ditto	4
Copper Ladles	13-Inch	2
	10 ditto	2
Wooden Stools		2
Tow, lbs.		2½
Block Knife		1
Form with Staple		1
Dutch Pumps		2
Mealing Tables		1
Copper	Shovels	1
	Slices	1
Rubbers, Wood		1
Hand Brush		1
Copper Keys and Vices for opening the Barrels, of each		1
Hair Sieves and Covers		1
Quick-match, lengths		1000
Deal Boxes for Composition		2
Wood Slices		2
Brown Paper, quires		6
Coarse Twine, lbs.		4
Tin Boxes for Mixing Priming		1
Lifting Tongs	13-Inch	1
	10 ditto	1
Round Tubs		2
Brass Prickers for Vents		2
Wood Bottoms	13-Inch	40
	10 ditto	40
Copper Scales, with Beams, pairs		1

Brass Weights, 4lb. sets			1
Scrapers for Shells		13-Inch	2
		10 ditto	2
Canvas Awnings			1
Portfire Sticks			4
Wood Setters		13-Inch	4
		10 ditto	4
Empty Fuzes		13-Inch	500
		10 ditto	500
Hair Cloths			2
Tanned Hides			6
Leather Buckets			6
Hand Hatchets			2
Baskets, ½-Bushel			4
Leather Powder Bags			3
Laboratory Chest			1
Deal Cases			3
Ammunition Boxes			120
Barrels	Water-tight, Half		4
	Common	Whole	31
		Half	44
		Quarter	1
Elm Plugs, 10-Inch			40
Firkins for Tallow and Soap			2
Rockets, Signal		1lb.	6
		½ ditto	18
Round Shot	Gun	6-Pounder	120
	Carronade	24 ditto	480
		12 ditto	60
	Mortar	1 ditto	5000

Shot	Grape.	Gun	6 Pounder	20
		Carronade	24 ditto	64
			12 ditto	12
	Case	Gun	6 ditto	20
		Carronade	24 ditto	
			12 ditto	
Blue-Lights				36
Powder for the Guns and Carronades, Half Barrels				38
Cartridges		Gun, 6-Pounder		164
		Carronade	24-Pounder	608
			12 ditto	84
		Small-Arm	Musquet	100
			Pistol	300

Stationery.

Books	Supply	1
	Expence	1
Abstracts		24

The proportion of powder for the mortars must be calculated according to the number of shells, carcasses, &c. Each full sea service charge is as follows:—

Full Charge for the Mortars	13-Inch,	20lbs.	10 ozs.	Powder.
	10 ditto,	9 do.	8 do.	ditto.

In the calculation, the bursting powder for the shells must also be considered.

The shells, carcasses, powder, and fuzes are the only stores which have particular places fitted up for their reception. The shells (empty) are stowed in lockers, called shell-rooms, in the fore and after holds. The

carcasses are secured in separate cases, on shelves, in a frame-work directly under the mortars, and the powder and composition in the magazine.

The filling-room and artillery store-room are in the cock-pit, and in these rooms the fuzes and small stores are arranged, in cases, ready for use.

INSTRUCTIONS FOR THE MANAGEMENT AND SECURITY OF BOMB-VESSELS IN ACTION.

1. The mortars, mounted on their beds, in the midships of the gun-deck, traverse on circular platforms, and may be fired over either side of the ship.

2. The booms must be wetted before the tarpaulins and mortar-hatches are taken off. This being done, the explosion bulk-head, of three-inch plank, must be placed between the mortars and the after part of the vessel, and tarpaulins nailed round the after hatchway, to secure the magazine and filling room from fire.

3. The mortars must never be fired at lower angles than 45 degrees. When at sea, they are lashed down to their platforms, the bolsters being previously removed to allow them to rest upon the transoms of the beds.

4. A non-commissioned officer and two gunners should be told off to the filling room to measure out the charges and fix the shells; one non-commissioned officer and three gunners for the service of each

mortar; and one gunner to receive the 13-inch shells, and lower them into the mortar. These men should be assisted in their several duties by a detachment of the crew.

5. The officer of marine artillery lays the mortars, with a plummet, in the usual manner, standing on the quarter-deck. The fuzes should be cut by a non-commissioned officer or steady gunner, under the immediate superintendance of the officer. The forecastle is the most convenient place for this purpose, as the officer can there readily make any alterations required, without being under the necessity of sending messages to the filling-room, which are always liable to mistakes.

6. The shells are hoisted on deck by means of a pulley or whip. The 13-inch shells are lowered into the mortar by a second whip, made fast to the main-stay, directly over its mouth; the 10-inch shells are carried along the gang-way by two men with a shell-beam, and lowered into the mortar by hand.

7. Previously to firing, the doors of the bulk-head under the quarter-deck must be shut, to prevent the cabins being injured by the explosion.

8. In taking their stations previously to a bombardment, it is desirable that the vessels should keep without the range of the enemy's batteries, or at a distance of 3000 yards from them, and that they should have springs upon their cables.

BREACH.

The best place for making a breach, both in the ravelin and bastion, is about 15 fathoms from their saliant angles.

The batteries should commence, for this purpose, by marking out, as nearly as possible, by their fire, the extent of the breach intended to be made :—first, by striking out a horizontal line as near the bottom of the revêtement as possible, and next by aiming at two others perpendicular to, and at the extremities of, this line. Then, by continuing to deepen these three cuts, and occasionally firing salvoes at the part to be brought down, the wall will in time give way in a mass. The guns must begin by firing as low as possible in the commencement of the operation, afterwards something higher, in the same manner as before, and so continue gradually advancing upwards till the breach is effected; for should they fire too high at first, the rubbish would cover the lower part of the wall, retard the operation, and tend to render the breach impracticable.

A breach of considerable extent may, with a given number of guns, be formed in one, or, at most two days, as is shown by the following practice at the sieges of Cuidad Rodrigo, and Badajoz.

Time of Firing at Cuidad Rodrigo.

On the 16th of January, 1812, at this place, the sun rose at 16 minutes past 8 o'clock, and set at 54 minutes

past 4; giving 8 hours and 38 minutes for the time of firing, or, in round numbers, 8 hours and a half.

January, 1812.	Hours.
14th.—Firing from 20, 24-pounders, and 2, 18-pounders	1
15th.—The whole day from 23, 24-pounders, and 2, 18-pounders to form the great breach	8½
16th.—Foggy weather, firing from 23, 24-pounders, and 2, 18-pounders	1
17th.—Foggy weather, firing from 23, 24-pounders and 2, 18-pounders, but cleared up at noon	5
18th.—Clear weather, from 30, 24-pounders, and 2, 18-pounders, to form the large and small breaches	8½
19th.—Clear weather, from 30, 24-pounders. At 4 p. m. both breaches considered as practicable, fire turned on defences, and place assaulted, 9 p. m.	8½
Total firing	32½

There was expended at this siege 8950, 24 pounder, and 563, 18-pounder round shot, making a total of 9515 rounds.

By this it appears that 292·76 rounds were fired from the ordnance in each of the 32½ hours, in battering, or otherwise.

Three hours firing, or 878 rounds being given to the defences, and one-fourth of the remaining time and ammunition, viz. 2159 rounds for the flank or small breach,—that breach being 30 feet wide, and the large one 100,—there will then remain 647·8 rounds for the great breach.

Thus, 40, 24-pounders, iron, with an expenditure of 164 rounds to each, being 6560, would have more than rendered the large breach practicable in 8½ hours, or during day-light.

But supposing 878 rounds to be more than was fired at the defences, and even allowing this quantity, together with 6560 rounds to have been expended upon the great breach, i. e. a total of 7438 rounds, then 46, 24-pounders would undoubtedly have rendered it practicable in 8½ hours.

The two breaches were formed from a distance of between 500 and 560 yards.

Time of Firing at Badajos.

On the 4th April, 1812, the sun rose at 7 minutes past 6, and set at 6 minutes past 7, being, from rising to setting, 12 hours, 59 minutes; or, for calculation, 13 hours for battering.

March, 1812.			Hours.
30th,	No. 9— 8, 18-pounders		13
31st,	.... 8, 18-pounders No. 7—12, 24-pounders No. 8— 6, 18-pounders	26 Guns	13
		Carried over	26

		Brought forward	26
April	1st	26 guns as before	13
	2d	ditto	13
	3d	ditto	12
	4th	ditto	13
	5th	ditto	13
	6th	ditto, 14 of which to form curtain breach	13
		Total firing	104

There was expended, of round shot, at this siege 18832, 24 pounders, and 13029, 18-pounders, making a total of 31861 rounds.

The three breaches, of which the curtain one was 40 feet wide, the flank one 90 feet, and the large one in the face of a bastion 150, were rendered practicable from a distance of between 6 and 700 yards.

Fourteen of the iron 18-pounders used for battering were Russian guns, but mounted on English travelling carriages, and cast at Carron, in Scotland. The shot fired from them were principally English; and as the calibre and consequent windage* were greater with the English shot, they did not strike the wall with so much force as if projected from British ordnance of the same nature.

* The calibre of a Russian 18-pounder is 5·45 inches—that of an English one, 5·29. The English shot being 5·04, the Russian gun gave a windage of ·41, while the English, with its own shot, only ·25.

It is also necessary to remark upon the superior effects of the 24-pounder shot over the 18-pounder, with proportionate charges from Russian or English guns, since 13029 rounds of the latter ammunition were expended in battering. But notwithstanding the disadvantage of an increased windage, and so much 18-pounder instead of 24-pounder shot being used, it will be seen that a certain number of 24-pounder, iron, guns would have made the large breach in 13 hours.

As 6, 24-pounders, and 4, 18-pounders, besides some of the 16, 24-pounders, iron, howitzers, were used en enfilade, about one-fourth of the 31861 24, and 18-pounder shot may be said to have been expended in that manner, thus leaving 23896 rounds to form the three breaches.

It has been shewn that the curtain breach of 40 feet was made on the 6th of April by 14 guns, and a consequent expenditure of 3514 rounds, there then remains 20382 rounds for the other two breaches.

The flank breach was 90 feet wide, and the large one 150 :—therefore, as the former was to the latter in the proportion of 3 to 5, it surely will be allowed that the time and ammunition spent on both were proportional to those numbers, there then remains 12230 rounds for the great breach.

Suppose, then, 50 iron 24-pounders to have been put in battery to breach with the proportionate expenditure of 251 rounds in 13 hours, being 12550 rounds,

the large breach of 150 feet would have been more than complete in 13 hours by 320 rounds.

It is evident, therefore, even in this case, and with so large a breach, that a second day's battering, and consequent expenditure of 25100 rounds from the 50, 24-pounders could not be necessary.

BRIDGES.

In the construction of a military bridge, the two principal points to be attended to are, *Strength* and *Buoyancy*. Ample information upon the first point will be found under the head of *Materials;* with regard to the latter, we shall here add the following necessary observations.

OF THE BUOYANCY OF BODIES.

If a body be either wholly or partly immersed in a fluid, it will occupy a space which was before occupied by a bulk of the fluid equal in magnitude to the body, or part of it immersed; and, previously to the immersion, the pressure downwards upon the fluid, below the place subsequently occupied by the body, being equal to the weight of the bulk of fluid displaced by the immersion, the upward reaction of the fluid, below the body, will be equal to that weight:—otherwise the fluid would not be in equilibrio both before and after the immersion, and the descent of the body in the fluid is impeded by that reaction.

Consequently, when a body is entirely immersed in a fluid of the same specific gravity as itself, it will remain at rest in it, because the upward reaction of the fluid is equal to the weight of the body; and the body may farther be said to have lost all its weight by the immersion.

If the specific gravity of the body be greater than that of the fluid, the body will sink, because its weight is greater than the upward reaction of the fluid; but that reaction impedes the descent with a force equal to the weight of the fluid displaced, and the body may be said to have lost just so much of its weight by the immersion, as is equal to the weight of a bulk of the fluid of the same magnitude.

Again, if the specific gravity of the body be less than that of the fluid, the body will float in it; but, at the same time, it will sink to a depth at which the pressure arising from its weight is equal to the upward reaction of the fluid, or till the pressure and reaction are in equilibrio. In which case the weight of the displaced fluid is equal to that of the body immersed. Hence, when a body floats in any fluid, it displaces just so much of it as is equal to the weight of the body.

From these principles we obtain the following practical rules for computing the buoyancy of materials, and thereby are enabled to apply them to the formation of floats or rafts to support given weights.

I. To find the Number of Planks required to form a Float to support a given Weight.

First, find the content of one plank, and multiply it by the specific gravity of the wood;—the product will be the weight of the timber.

Second, multiply the same solid content by the specific gravity of water;—the product will be the weight of an equal bulk of water.

Then, take the difference of these two products or weights, and it will be the weight one piece of timber will support without sinking.

Hence, by proportion, we may find the number required to support the given weight.

II. To find the Number of Casks required to form a Raft to support a given Weight.

First, find the solid content of one cask, in cubic inches, and multiply it by the specific gravity of water; —the product will be the weight of a quantity of water of equal bulk with the cask.

Second, from this product or weight, subtract the weight of the cask, and the remainder will be the weight it will support without sinking.

Then, by proportion, the number required for the formation of the raft may be found.

III. To find the Number of Boats or Pontoons required to support a given Weight.

When it is required to find the burthen a boat or

pontoon will support, without sinking beyond a given depth—the form of the boat or pontoon being known.

First, find the solid content, in cubic feet, of the part to be sunk, and multiply it by the specific gravity of water.

Second, subtract this product from the weight of the boat or pontoon, and the remainder will be the burthen it will support without sinking beyond the required depth.

Then, by proportion, we may compute the number required to support the given weight.

These three problems, together with the observations upon which they are founded, and the remarks on the resistances and velocities of fluids, comprise, in a few words, the whole science of constructing what may, without impropriety, be termed the foundation of a floating bridge.

OF THE MANNER OF LAYING A PONTOON, OR OTHER FLOATING BRIDGE, ACROSS A RIVER.

The situation of the bridge being determined on, and the breadth of the river and the rapidity of its current ascertained, the first operation is to prepare roads from the banks to communicate with those by which the troops are to advance. If the banks are steep, they must be reduced to an easy slope, and those parts on each side, where the extremities of the bridge are to rest, made as solid and firm as possible, by means of hurdles, fascines, or otherwise.

In the mean time, a sheer-line, or cable, must be stretched across the river, and, when fastened to a tree, camp picket, or any thing firm on the opposite bank, hove taught by means of a crab-capstan, or temporary windlass, formed of the shafts, axle-tree, and one of the wheels of a pontoon or gun carriage. If the place of each individual pontoon were marked upon the sheer-line, previously to its being stretched, much time, and considerable confusion, in afterwards arranging the boats in their proper situations, would be avoided.

The pontoons, each with its proper proportion of baulks, chesses, &c. and two men on board of it, should be launched into the river, and arranged along the bank in the order they are afterwards to assume in the bridge; that is to say, those intended to form its furthest extremity, should be ranged highest up the stream.

The boats are floated or punted down the stream to their respective stations, along the sheer-line; to which they are moored by the head lashings as soon as the intervals are properly taken up.

If the river be very rapid, a second sheer-line must be stretched across it, parallel to the first, and at the distance of the length of the boats, and to which the other ends of them must be lashed. The spring-lines are then passed diagonally from pontoon to pontoon, and the belaying sticks are fixed to brace them tight as soon as it is ascertained they are in their true posi-

tions. The anchors, if necessary, should also be carried up the stream, and dropped in such situations that the cables may, as far as practicable, form equal angles with the surface of the water. If this precaution in dropping the anchors be not attended to, the strain upon the bridge will be unequally divided.

The foundation being thus prepared, one of the chesses is next laid on the edge of the bank, at each end of the bridge, bottom up:—these serve to lay the ends of the baulks upon, and as a direction for placing them at the proper distances apart, to fit the chesses that cover the bridge.

The baulks of the first pontoon should then be laid across the boats, and those of the second bolted to them, and the line thus prolonged across the river. Their numbers being proportioned to the strength required in the bridge.

The chesses are laid across the baulks, one after another, the edges to meet, and the baulks running between the cross pieces on the under sides of them. If the gang-boards are laid across the heads and sterns of the boats, from one side of the river to the other, they will, by forming a footing for the men, very much facilitate the operation of laying the chesses.

Lastly, the gang-boards are laid along the ends of the chesses on each side of the bridge.

With a well arranged train of pontoons, and expert pontooneers, the time required to construct a bridge is at the rate of a minute and a half for each pontoon.

PRECAUTIONS NECESSARY TO BE OBSERVED IN PASSING A BRIDGE OF BOATS.

Of whatever size a bridge may be, infantry should never be allowed to pass at the same time with carriages or cavalry. The carriages should always move at a certain distance behind each other, that the bridge may not be shaken by being overloaded.

Horses should not be allowed to trot over the bridge, and the cavalry should dismount and lead their horses over.

Large droves of cattle must not be allowed to pass at the same time.

For the dimensions, weight, and equipage of a pontoon, see the word Pontoon.

When the bridges are made to facilitate the communication between the different parts of the approaches at a siege, they should, if possible, be placed above the town; or the besieged will take advantage of the current to float down large trees, or other bodies, in order to destroy them. Two such bridges should always be placed close to each other, in order to prevent the confusion arising from crossing and re-crossing upon the same bridge; the one being intended to pass over one way, and the other to return.

A pontoon bridge of the old pattern will not, in general, support a greater weight than four or five thousand pounds. When the pontoons are united in a bridge, they will, no doubt, bear more than when

acted upon separately:—the weight, however, which each will bear may be easily ascertained, either by the rule already given for that purpose, or by loading it with water till it sinks to any required depth, and then by calculating the number of cubic feet of water it contains, ascertain the number of pounds required to sink it to that particular depth.

CAMP.

With some trifling variations, camps are formed after the same manner in all the European armies. This principle seems general, that the extent of the camp in front do not exceed the length of line occupied by the troops when drawn out in order of battle.

An army is sometimes encamped in two lines, and sometimes in three; and the distance between the lines varies, according to the face of the country, from 200 to 600 yards, or more.

Distribution of the Front of a Camp for a Battalion of Infantry, or Squadron of Cavalry.

In regulating the front of a camp, two feet are generally allowed for every file of infantry, and three feet for each file of cavalry. When the ground will permit, the tents of the infantry are usually arranged in rows perpendicular to the front, each row containing those of a company; and the cavalry are disposed in the same position, each perpendicular row containing the tents and horses of a troop.

The grenadier and light infantry companies are usually placed in single rows on the flanks, and the battalion companies in double rows in the interval between them.

A single row, or one company, occupies in front 17 feet, being the diameter of the tent; and a double row, or two companies, 36 feet; if formed of the new pattern circular tents, which are calculated to hold 15 men each.

In the cavalry a single row, or troop, occupies a front as follows:—

	Yards.	*Feet.*	
Tent	5	2	19 yards
From the outside of the tent to the picket rope	5	1	
For the horse	6	0	
For the manure	2	0	

The breadth, therefore, of a row in front, whether for infantry or cavalry, being multiplied by the number of rows, and the product subtracted from the whole extent of front required for a battalion of infantry, or squadron of cavalry, will leave the space for the streets; which, if they are to be of equal breadths, must be divided by their proposed number to find the breadth of each; or it is otherwise easily divided into streets of unequal breadths.

If the ground on which the camp is to be formed will not admit of each troop or company being arranged in one row perpendicular to the front, the

above distribution must be contracted and laid out as follows:—Find how many perpendicular rows will be required, by dividing the number of tents occupied by the battalion or squadron, by the number the ground will admit of in one row; then the number of rows being multiplied by the breadth of one in front, will give that part of the front to be occupied by the tents; and, as before, the difference between it and the whole extent of front allowed for the battalion or squadron will be the part left for the streets.

If the battalion or squadron be encamped in single rows, the number of streets will be one less than the number of rows. Should the battalion, however, be encamped with its flank companies in single, and battalion companies in double rows, the number of streets will be equal to half the number of companies.

Distribution of the Depth of a Camp for a Battalion of Infantry, or Squadron of Cavalry.

		Infantry.	*Cavalry.*
These tents open to the front....	From the quarter guard parade to the line of parade of the Battalion	62 yards.	
	From this first line of parade to the first tents...	16	24 yds.
	Carried forward	78 yds.	24 yds.

		Infantry.	*Cavalry.*
	Brought forward	78 yds.	24 yds.
The infantry tents open to the streets and the cavalry tents to the horses' heads....	To the first picket of horses....		5
	For every tent in depth	6	6
	For every horse ..	3	3
These tents open to the rear	From the infantry tent, or cavalry horses, to the front of the subalterns' tents....	15	12
The captains' and subalterns' tents should be placed in rear of their respective troops or companies. The former open to the front	To the front of the captains' tents	15	15
The field officers' tents should open to the front, and be placed opposite the outside streets of the battalion or squadron	To the field officers' tents.....	10	15
Opens to the front opposite the centre street of the battalion or squadron	To the colonel's tent	10	10
	Carried forward	137 yds.	90 yds.

		Infantry.	*Cavalry.*
	Brought forward	137 yds.	90 yds.
These tents open up the streets adjoining the centre street ..	To the staff officers'	10	14
The bâtmen's tents open to their horses' heads	To the bâtmen's tent	10	15
	To the first pickets for bât-horses	2	
	To the second rows of pickets for ditto	10	
	To the second row of bâtmen.	2	
The mess tent is usually placed in rear of the colonels'	To the front of the mess tent ..	10	10
The kitchens are generally 16 feet in diameter	To the centre of the kitchens....	15	20
These tents should be placed directly in rear of the kitchens	To the front of the sutlers' tent	15	15
Opens to the rear............	To the rear guard...........	15	15
Total depth required		226 yds.	179 yds.

The above is the usual depth allowed for each line of tents, when the ground will admit of it; it only con-

tains, however, the depth required for the head tent of each perpendicular row; consequently, in estimating the depth, the number of tents in a row, minus one, must be added to the above distribution. See also the word PARK OF ARTILLERY.

CAMPHOR

Is a vegetable production, resembling the volatile oils, from which it is deposited in pretty large quantities, after long standing. It has been obtained in small quantities by distillation, with water, from thyme, rosemary, sage, and other aromatic plants. The camphor of commerce, however, is obtained from a species of laurel, which grows in China, and the Indian islands, by distillation of the wood and other parts of the tree with water. The camphor rises by the heat, and is afterwards purified by a repetition of the process, with the addition of about one-twelfth of its weight of lime.

This substance is much more volatile than essential oils. It cannot be preserved without loss, but in closed vessels; and even in these, it sublimes by the heat of summer. Water does not dissolve it, but it is plentifully soluble in spirits of wine, in ether, and in concentrated acids; from all which it is separated, without alteration, by the addition of water. It is, from its peculiarly inflammable qualities—burning in water—an excellent ingredient in firework compositions; it has a clear flame, and gives out an agreeable odour.

The best camphor is without stain, white, friable, and transparent.

CARCASSES.

There were formerly two species of carcasses in the service:—viz., the old oblong carcasses, a description of which will be found under the head of *Light-Balls*, which they very much resembled; and the modern round carcasses. The only difference between the cases of the latter kind, and common shells, consists in their having four fuze-holes in one of their hemispheres.

The round are the only species now employed; the use of the oblong being discontinued, on account of the uncertainty attending their ranges.

Weight and Dimensions of Round Carcasses.

Nature of Carcasses.		Diameter.	Weight, Empty.				Composition.		Weight, Filled.			
		In.	cwt.	qrs.	lbs.	ozs.	lbs.	oz.	cwt.	qrs.	lbs.	ozs.
Land Service.	13-Inch	12·84	1	2	27	0	17	14	1	3	16	14
	10 do.	9·85	0	3	6	4	7	4	0	3	13	8
	8 do.	7·85	0	1	20	0	2	14	0	1	22	14
	42-Pr.	6·85	0	1	0	14	1	12	0	1	2	10
	32 do	6·10	0	0	23	3¼	1	4½	0	0	24	8
	24 do.	5·54	0	0	15	6	1	3½	0	0	16	9½
	18 do.	5·04	0	0	13	12	0	11½	0	0	14	7
	12 do.	4·4	0	0	8	6	0	7	0	0	8	13
Sea.	13-Inch	12·85	1	3	17	12	14	8	2	0	4	4
	10 do.	9·85	0	3	13	0	6	6	0	3	19	6

Composition.

Saltpetre, 6 pounds, 4 ounces; sulphur, 2 pounds, 8 ounces; antimony, 10 ounces; rosin, 1 pound, 14 ounces; tallow, 10 ounces; turpentine, 10 ounces.

The above proportion of ingredients is to be mixed in precisely the same manner as those for light and smoke-balls.

At the siege of Quebec, it was found that the quantity of powder requisite for throwing the carcasses into the town, always destroyed them; the plan of filling the interval between the powder and carcass with turf was adopted, and found to preserve the carcass, and produce every desired effect.

The following Proportions of Materials are required for making Ten Round Carcasses of each Nature:—

Description of Materials.		Nature of Carcass.				
		13-Inch.	10-Inch.	8-Inch.	$5\frac{1}{2}$-Inch.	$4\frac{2}{5}$-Inch.
Carcasses, Round ……		10	10	10	10	10
Saltpetre, Ground ..	lbs. ozs.	93 12	37 8	14 8	6 4	5 12
Saltpetre, Pulverized	ditto..	4 14	2 15	0 12	0 8	0 6
Sulphur, Ground ..	ditto..	37 8	15 0	5 13	2 8	2 4
Sulphur, Sublimed.	ditto..	1 8	0 12	0 3	0 2	0 1
Rosin ……..	ditto..	28 12	11 4	4 1	1 14	1 10
Powder, mealed.	ditto..	4 2	2 0	0 15	0 11	0 9
Antimony ……	ditto..	9 6	3 12	1 8	0 10	0 8
Tallow ……..	ditto..	9 6	3 12	1 8	0 10	0 8
Turpentine, Venice	ditto..	9 6	3 12	1 8	0 10	0 8
Kitt ……….	ditto..	5 0	4 8	4 0	2 8	1 8
Match ……..	ditto..	0 5	0 4	0 2	0 $1\frac{1}{2}$	0 $1\frac{1}{4}$
Hessian……..	yards..	$1\frac{1}{4}$	1	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{5}{8}$

Valenciennes composition, so called from its having been used by the Austrians at the siege of that place, has the effect of making shells answer the purpose of carcasses when they burst.

Saltpetre..................	50	parts
Sulphur	24	
Antimony	18	
Rosin......................	5	

This composition is cast in copper cylindric moulds, of six inches long, and of different diameters, according to the fuze holes of the shells in which it is to be used. It must be put in at the same time as the bursting powder, in pieces as large as the shells will admit, without preventing the fuzes from being driven down.

CARRIAGES.

Weight, dimensions, &c. of gun carriages.

I.—Field Carriages.

18-*Pounder Gun, Iron.*

		cwt. qr. lb.		
Gun, &c.	Gun	38 2 0	56 0 21 (Gun and Carriage)	63 2 3
	Carriage	17 2 21		
	Limber		7 1 10	
Wagg. &c.	Limber	8 2 18	13 3 6 (Limber and Ammunition)	29 0 21
	Ammunition	5 0 16		
	Body	8 3 23	15 1 15 (Body and Ammunition)	
	Ammunition	6 1 20		

Medium 12-*Pounder, Brass.*

		cwt.	qr.	lb.	Subtotal (cwt. qr. lb.)	Total (cwt. qr. lb.)
Gun, &c.	Gun	18	0	0	30 3 9	42 0 23
	Carriage	12	3	9		
	Limber	8	3	6	11 1 14	
	Ammunition	2	2	8		
Wagg. &c.	Limber	8	1	4	12 3 12	28 2 16
	Ammunition	4	2	8		
	Body	8	3	20	15 3 4	
	Ammunition	6	3	12		

Light 12-*Pounder, Brass.*

		cwt.	qr.	lb.	Subtotal (cwt. qr. lb.)	Total (cwt. qr. lb.)
Gun, &c.	Gun	12	0	0	23 2 9	36 0 18
	Carriage	11	2	9		
	Limber	8	1	5	12 2 9	
	Ammunition	4	1	4		
Wagg. &c.	Limber	8	1	5	12 2 9	27 3 25
	Ammunition	4	1	4		
	Body	8	3	20	15 1 16	
	Ammunition	6	1	24		

9-*Pounder, Brass.*

		cwt.	qr.	lb.	Subtotal (cwt. qr. lb.)	Total (cwt. qr. lb.)
Gun, &c.	Gun	13	2	0	25 1 6	37 0 5
	Carriage	11	3	6		
	Limber	8	0	17	11 2 27	
	Ammunition	3	2	10		
Wagg. &c.	Limber	8	0	17	11 2 27	27 2 13
	Ammunition	3	2	10		
	Body	8	3	24	15 2 14	
	Ammunition	6	3	18		

Heavy 6-Pounder, Brass.

		cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.
Gun, &c.	Gun	12	0	0	23	0	26	35	0	2
	Carriage	11	0	26						
	Limber	8	0	24	11	3	4			
	Ammunition	3	0	8						
Wagg. &c.	Limber......	8	0	24	11	3	4	27	3	17
	Ammunition	3	2	8						
	Body	8	3	21	16	0	13			
	Ammunition	7	0	20						

Light 6-Pounder, Brass.

		cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.
Gun, &c.	Gun	6	0	0	15	0	26	26	0	15
	Carriage	8	3	6						
	Ammunition	0	1	20						
	Limber......	8	0	5	10	3	17			
	Ammunition	2	3	12						
Wagg. &c.	Limber......	8	0	5	11	1	25	27	2	6
	Ammunition	3	1	20						
	Body	8	3	21	16	0	9			
	Ammunition	7	0	16						

Heavy 3-Pounder, Brass.

		cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.
Gun, &c.	Gun	6	0	0	14	3	4	25	2	17
	Carriage	8	1	24						
	Ammunition	0	1	8						
	Limber......	8	0	6	10	3	13			
	Ammunition	2	3	7						
Wagg. &c.	Limber......	8	0	6	10	3	13	26	2	3
	Ammunition	2	3	7						
	Body	8	3	18	15	2	18			
	Ammunition	6	3	0						

8-*Inch Howitzer, Iron.*

		cwt. qr. lb.		
Howitz. &c.	Howitzer....	20 2 0	42 2 0	49 3 10
	Carriage	22 0 0		
	Limber		7 1 10	
Wagg. &c.	Limber......	8 1 14	13 0 22	28 3 19
	Ammunition	4 3 8		
	Body	9 1 5	15 2 25	
	Ammunition	6 1 20		

24-*Pounder Howitzer, Brass.*

Howitz. &c.	Howitzer....	12 0 0	24 2 0	37 0 19
	Carriage	12 2 0		
	Limber	8 1 3	12 2 19	
	Ammunition	4 1 16		
Wagg. &c.	Limber......	8 1 3	12 2 19	28 0 23
	Ammunition	4 1 16		
	Body	8 3 22	15 2 4	
	Ammunition	6 2 10		

$5\frac{1}{2}$-*Inch Howitzer, Brass.*

Howitz. &c.	Howitzer....	10 0 0	22 3 15	35 2 6
	Carriage	12 3 15		
	Limber......	8 1 3	12 2 19	
	Ammunition	4 1 16		
Wagg. &c.	Limber......	8 1 3	12 2 19	28 0 23
	Ammunition	4 1 16		
	Body	8 3 22	15 2 4	
	Ammunition	6 2 10		

12-*Pounder Howitzer, Brass.*

		cwt. qr. lb.		cwt. qr. lb.
Howitz. &c.	Howitzer....	6 2 13	16 1 17	27 3 24
	Carriage	9 3 4		
	Limber......	8 0 21	11 2 7	
	Ammunition	3 1 14		
Wagg. &c.	Limber......	8 1 3	11 2 17	25 3 11
	Ammunition	3 1 14		
	Body	8 3 22	14 0 22	
	Ammunition	5 1 0		

Spare Gun and Wheel Carriages.

		cwt. qr. lb.		
18-Pr. Iron.	Limber	7 1 10	.. ..	.. ..
	Wheelers' Tools			
	Carriage	17 2 21	29 0 9	
	Spare Articles	11 1 16		
12-Pr Medium	Limber......	8 2 11	.. ..	.. ..
	Wheelers' Tools			
	Carriage	13 1 21	22 2 10	
	Spare Articles	9 0 17		
12-Pr. Light.	Limber	7 3 11	.. ..	.. ..
	Wheelers' Tools			
	Carriage	12 0 16	21 1 12	
	Spare Articles	9 0 24		
9-Pr.	Limber	7 3 11	.. ..	.. ..
	Wheelers' Tools			
	Carriage	12 2 14	21 3 8	
	Spare Articles	9 0 22		

		cwt.	qr.	lb.		
6-Pr. Heavy.	Limber	7	3	11		
	Wheelers' Tools				.. ..	
	Carriage	11	2	4		.. ..
	Spare Articles	9	0	22	22 2 26	
6-Pr. Light.	Limber	7	3	11		
	Wheelers' Tools				.. ..	
	Carriage	9	2	12		.. ..
	Spare Articles	7	3	3	17 1 15	
3-Pr. Heavy.	Limber	7	3	11		
	Wheelers' Tools				.. ..	
	Carriage	9	0	15		.. ..
	Spare Articles	7	3	3	16 3 18	
8-Inch Howitz. Iron.	Limber	7	1	10		
	Wheelers' Tools				.. ..	
	Carriage	22	0	0		.. ..
	Spare Articles	11	1	16	33 1 16	
24-Pr. or $5\frac{1}{2}$ In. Howitz.	Limber	8	1	3		
	Wheelers' Tools				.. ..	
	Carriage	12	2	2		.. ..
	Spare Articles	8	3	24	21 1 26	
12-Pr. Howitz.	Limber	8	0	21		
	Wheelers' Tools				.. ..	
	Carriage	9	3	4		.. ..
	Spare Articles	7	3	3	17 2 7	

		cwt. qr. lb.		
Forge-Wagg.	Limber	7 3 11	9 3 16	23 1 1
	Smith's Tools	2 0 5		
	Body	9 0 8	13 1 13	
	Bellows	0 2 15		
	Anvil and Bick Iron	1 2 18		
	Iron, Coals, &c.	2 0 0		
Store-Limber Wagg.	Limber	7 3 11	.. ..	.. ..
	C.M.'s Tools			
	Body	10 0 11	21 0 2	
	Stores, &c...	10 3 19		

II.—MOUNTAIN SERVICE CARRIAGES.

Light 3-Pounder, Brass.

On Mule Back.	Gun	2 1 0	4 0 20	8 2 22
	Carriage	1 3 20		
	Ammunition in four boxes	.. ..	4 2 2	
By Draft	Gun	2 1 0	4 2 4	9 0 1
	Carriage	2 1 4		
	Ammunition in six boxes	.. ..	4 1 25	

Light $4\frac{2}{5}$-Inch Howitzer, Brass.

On Mule Back.	Howitzer....	2 2 0	4 3 2	11 2 20
	Carriage	2 1 2		
	Ammunition in six boxes	.. ..	6 3 18	
By Draft	Howitzer ..	2 2 0	5 0 14	14 2 4
	Carriage	2 2 14		
	Ammunition in ten boxes	.. ..	9 1 18	

III.—COLONIAL SERVICE CARRIAGES.

					cwt. qr. lb.
Light 3-Pr.		Gun	3 0 0	7 0 3	11 1 23
		Carriage	4 0 3		
		Limber	3 1 18	4 1 20	
		Ammunition	1 0 7		
		Car.	3 3 14	.. ..	5 3 26
		Ammunition	2 0 12		
1-Pr. Ammuzette.	Old Pattern.	Gun	2 2 0	6 0 9	10 0 9
		Carriage	3 2 9		
		Limber	3 1 2	4 0 0	
		Ammunition	0 2 26		
		Car.	3 3 14	.. ..	5 1 11
		Ammunition	1 1 25		
	New Pattern.	Gun	2 2 0	6 3 14	8 3 8
		Carriage	2 0 26		
		Ammunition in four boxes	2 0 16		
		Ammunition in two boxes	.. ..	1 3 22	
Light $4\frac{2}{5}$ Inch How.		Howitzer....	2 2 0	7 3 2	12 1 14
		Carriage	5 1 2		
		Limber	3 1 16	4 2 12	
		Ammunition	1 0 24		
		Car.	3 3 20	.. ..	6 1 12
		Ammunition	2 1 20		

IV.—TRAVELLING AND TRANSPORTING CARRIAGES.

24-Pr.	Gun	47 2 0	79 1 0
	Carriage	24 1 18	
	Limber	7 1 10	

			cwt.	qr.	lb.	cwt.	qr.	lb.
18-Pr.	Gun		38	2	0	63	1	3
	Carriage		17	1	21			
	Limber		7	1	10			
12-Pr.	Gun		32	2	0	56	0	10
	Carriage		16	1	0			
	Limber		7	1	10			
10-In. How.	Howitzer		39	2	20	76	2	6
	Carriage		29	2	4			
	Limber		7	1	10			
8-In. How.	Howitzer		20	2	0	49	3	10
	Carriage		22	0	0			
	Limber		7	1	10			
Carriages.	Platform					21	0	23
	Devil, Large	Limber	10	0	22	28	3	1
		Body	18	2	7			
	Devil, Small					7	2	8
	Drug	Large				14	0	0
		Small				5	1	10
	Pontoon					12	1	8
Wagg.	Flanders					15	2	1
	Small-arm Ammn.	Limber	7	2	4	14	3	2
		Body	7	0	26			
	Baggage					18	0	0
Carts.	Trench					2	2	13
	Sling					16	2	2
	Baggage					8	3	14
	Hand					2	1	23

V.—Garrison and Ship Carriages.

Nature of Carriage.	Brackets. Bottom. Length.	Brackets. Bottom. Depth.	Brackets. Bottom. Thickness.	Brackets. Top. Length.	Brackets. Top. Depth.	Brackets. Top. Thickness.	Transoms. Length.	Transoms. Depth.	Transoms. Thickness.	Weight, with Trucks, &c. Complete.
	Ft. In.	Ft. In.	In.	Ft. In.	Ft. In.	In.	Ft. In.	Ft. In.	In.	cwt. qrs. lbs.
Garrison.										
42-Pounder	6 5·0	1 1·5	6·5	5 7·5	1 1·5	6·5	1 9·0	1 5·0	6·5	16 3 13
32 ditto	6 3·25	1 1·25	6·0	5 5·75	1 1·25	6·0	1 8·5	1 4·75	6·0	15 1 2
24 ditto	6 2·0	1 1·0	5·5	5 4·75	1 1·0	5·5	1 7·5	1 4·75	5·5	13 2 23
18 ditto	5 11·5	1 ·5	5·25	5 2·5	1 ·5	5·25	1 7·0	1 4·0	5·25	12 3 1
12 ditto	5 9·0	1 ·5	4·5	5 ·5	1 .5	4·5	1 4·0	1 4·5	4·5	11 2 7
9 ditto	5 8·5	1 ·0	4·25	5 ·0	1 ·0	4·25	1 4·0	1 4·0	4·25	10 1 13
6 ditto	5 7·75	1 ·0	3·75	4 11·0	1 ·0	3·75	1 3·0	1 3·75	3·75	9 0 20
4 ditto	4 6·0	0 9·5	3·75	3 11·0	0 9·5	3·5	1 1·0	1 0·5	3·5	6 3 20
3 ditto	3 9·0	0 9·5	3·25	3 4·0	0 9·5	3·25	1 1·0	1 0·5	3·25	6 1 24
Sea Service.										
68-Pounder	5 7·0	1 10·5	6·0	2 3·25	0 7·5	5·5	2 0·5	0 8·0	6·0	13 3 0
32.. 9 feet 6 in.	6 2·5	1 1·0	6·0	5 5·5	1 1·0	6·0	1 9·0	1 5·0	6·0	9 0 0
32.. 8 0	5 6·0	0 11·0	5·5	4 8·0	1 1·0	5·5	1 8·0	1 2·5	5·5	6 3 21
24.. 9 feet 6 in.	6 1·0	1 0·5	5·5	5 4·5	1 0·5	5·5	1 8·0	1 4·5	5·5	7 2 20
24.. 9 0	5 10·5	1 0·5	5·5	5 1·75	1 0·5	5·5	1 8·0	1 4·5	5·5	6 2 22
24.. 7 6	4 10·0	1 0·5	5·5	4 3·0	1 0·5	5·5	1 8·0	1 4·5	5·5	6 3 2
24.. 6, or 6 ft. 6 in	4 8·0	1 9·5	5·0				1 8·0	1 1·0	5·0	6 0 24
18.. 9 feet	5 9·5	0 10·25	5·0	5 1·0	10·25	5·0	1 6·5	1 1·0	5·0	5 3 17
18.. 8	5 4·0	0 11·25	5·0	4 8·0	11·25	5·0	1 6·5	1 2·0	5·0	5 2 12
18.. 6	4 8·0	0 10·5	4·5	4	10·5	4·5	1 6·0	1 1·25	4·5	5 1 10
12.. 9 feet 0 in.	5 7·0	0 9·75	4·5	4 11·5	9·75	4·5	1 5·0	1 0·5	4·5	4 3 20
12.. 8 6	5 4·5	0 9·5	4·5	4 9·0	9·5	4·5	1 5·0	1 0·5	4·5	4 2 13
12.. 7 6	4 11·0	0 9·25	4·5	4 4·0	9·25	4·5	1 5·0	0 11·75	4·5	4 1 5
9.. 9 feet 0 in.	5 5·0	1 5·5	4·0				1 4·5	0 10·25	4·0	4 3 24
9.. 8 6	5 3·0	1 5·5	4·0				1 4·5	0 10·25	4·0	4 3 21
9.. 7 6	4 10·0	1 5·25	4·0				1 4·5	0 10·25	4·0	3 3 7
9.. 7 0	4 7·75	1 5·0	4·0				1 4·5	0 10·25	4·0	3 1 0
6.. 8 0 in.	4 10·0	1 5·0	3·5				1 3·0	0 10·5	3·5	3 1 19
6.. 7 6	4 7·25	1 4·0	3·5				1 3·0	0 9·5	3·5	3 1 0
6.. 7 0	4 5·0	1 4·0	3·5				1 3·0	0 9·5	3·5	3 0 0
6.. 6 0	4 0	1 4·0	3·5				1 3·0	0 9·5	3·5	2 3 11
4	3 6·5	1 2·0	3·5				1 1·0	0 8·0	3·5	2 0 0
3	3 1·5	1 2·0	3·0				1 1·0	0 8·75	3·0	1 1 22

I

The 68-pounder carriage has, in addition to the breast transom in the above table, a centre and horizontal one of the following dimensions :—

	Centre.		*Horizontal.*
Length	2 feet, 10·5 inches	....	2 feet, 0·5 inches
Depth......	1 ditto, 2·0 ditto	....	1 ditto, 2·0 ditto
Thickness..	0 ditto, 6·0 ditto	....	0 ditto, 6·0 ditto

And also, a directing bar and guides of which the dimensions are as follows :—

	Directing Bar.		*Guides.*
Length	7 feet, 10·0 inches	....	3 feet, 9·5 inches
Breadth....	0 ditto, 9·0 ditto	....	0 ditto, 4·0 ditto
Thickness..	0 ditto, 4·5 ditto	....	0 ditto, 3·75 ditto

Block Trail Carronade Carriages.

NATURE OF CARRIAGE.	Trail.			Trail-bearing.			Weight.
	Length.	Width.	Thickness	Length.	Width.	Thickness	
	Ft In	Ft In	Ft. In.	Ft In	Ft. In.	Ft In	cwt. qrs. lbs.
68-Pounder .	7 0	2 1·5	1 3	1 8	1 0	8·0	17 1 25
24 ditto ..	5 2	1 4·0	0 11	1 6	0 10	5·5	7 3 21
18 ditto ..	5 0	1 3·0	0 11	1 6	0 9	7·5	4 3 20
12 ditto ..	4 6	1 0·5	0 10	1 4	0 8	7·0	6 1 0

Cast Iron Garrison and Carronade Carriages.

NATURE OF ORDNANCE.		Weight of		
		Cast Iron.	Wrought Iron.	Total.
		Cwts.qrs.lbs.	Cwts.qrs.lbs.	Cwts.qrs.lbs.
Guns..	42-Pounder	25 3 7	0 1 25	26 1 4
	32 ditto..	22 0 0	0 1 18	22 1 8
	24 ditto..	19 3 14	0 1 14	20 1 0
	18 ditto..	16 3 5	0 1 12	17 0 17
	12 ditto..	16 0 0	0 1 10	16 1 10
	9 ditto..	14 0 11	0 1 9	14 1 2
	6 ditto..	14 2 4	0 1 5	14 3 9
Carronades	32-Pounder	11 3 20	0 1 5	12 0 25
	24 ditto..			10 3 18
	12 ditto..	7 2 20	0 0 18	7 3 10
	6 ditto..			8 1 13

For the dimensions of the Axletrees, Trucks, Stool Beds, &c. see those words.

Howitzer Carriages.

			10-*Inch.*	8-*Inch.*
			ft. in.	ft. in.
Brackets.	Bottom (Wood.)	Length ..	6 0	5 0
		Width	1 10·5	1 9·5
		Thickness	0 6·5	0 6·0
	Top (Iron.)	Length ..	2 2·75	2 0
		Width	0 8.0	0 6·5
		Thickness	0 6·0	0 5·0

			8-Inch.		*10-Inch.*	
			ft.	in.	ft.	in.
Transoms	Breast.	Length ..	2	0	1	7·5
		Width	1	3·75	1	2·5
		Thickness	0	6·5	0	6·0
	Horizontal	Length ..	2	0	1	7·5
		Width	1	5·0	1	2·0
		Thickness	0	6·0	0	5·0
Trail Bearings. (Cast Iron.)		Length ..	0	11·5	0	11·5
		Width	0	4·75	0	4·75
		Thickness	0	4·0	0	4·0

	cwts. qrs. lbs.	*cwts. qrs. lbs.*
Weight, complete with Trucks, &c.	16 0 0	13 0 0

CARRONADES.

Weights and Dimensions of Carronades.

NATURE OF CARRONADE.	Calibre.	Length of Carronade in		Length of Bore in		Weight.			Proportion between the Shot and Carronade.
	In.	Calibres.	Inches.	Calibres.	Inches.	Cwt.	qr.	lb.	
68-Pr.	8·05	7·702	61·72	7·702	61·72	36	0	0	59
	8·05	5·962	48·0	5·962	48·0	29	0	0	
42 do..	6·84	7·518	52·425	7·518	52·425	22	0	0	58
32 do..	6·25	7·679	47·71	7·679	47·71	17	0	0	62
24 do	5·68	7·656	43·32	7·656	43·32	13	0	0	56
	5·68	6·336	36·0	6·336	36·0	11	2	0	
18 do	5·16	7·587	39·3	7·587	39·3	10	0	0	56
	5·16	5·447	28·0	5·447	28·0	8	1	0	
12 do..	4·52	5·778	32·361	5·778	32·361	6	0	0	56

CARTRIDGES.

Weight, Dimensions, &c. of Cartridges.

I.—CARTRIDGES FOR ARTILLERY.

General Table of Cartridges for Guns, Howitzers, and Carronades.

NATURE OF ORDNANCE.	Charge of Powder.	Dimensions.			Cartridges in each Box.	Weight of			Tonnage.
		Length.	Circumference.			Box.		Empty Cartridges (50).	
			Superior.	Inferior.		Empty.	Filled.		
	lbs.ozs.	Ft. In.	Ft. In.	Ft. In.		lbs.ozs.	lbs.ozs.	lbs.ozs.	cwts.qrs.lbs.
Guns (Iron). 68-Pounder	7	1 8·6	1						
42 ditto	14	1 11·1	1 9·4	1 9·4					
32 ditto	10 11	1 9·8	1 7·9	1 7·9					
24 ditto	8	1 6·3	1 5·6	1 5·6	10	36 13	120 3		
18 ditto	6	1 7·0	1 4·5	1 4·5					
12 ditto	4	1 4·5	1 2·5	1 2·5	12	28 2	78 14		
9 ditto	3	1 2·2	1 1·0	1 1·0	12	20 14	59 6		
6 ditto	2	1 1·1	1 1·5	1 1·5	24	25 8	75 12		

Nature of Ordnance.	Charge of Powder.	Dimensions.			Cartridges in each Box.	Weight of			Tonnage.
		Length.	Circumference.			Box.		Empty Cartridges (50)	
			Superior.	Inferior.		Empty.	Filled.		
	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.		lbs. ozs.	lbs. ozs.	lbs. ozs.	cwts. qrs. lbs
Guns (Brass). 12-Pounder Medium. . .	4	1 4·5	1 2·5	1 2·5	12	27 15	78 14		
Guns (Brass). 12-Pounder Light	3	1 1·5	1 2·5	1 2·5	12	20 14	59 6		
9 ditto	3	1 1·1	1 1·0	1 1·0	12	20 12	59 7		
6 ditto Heavy	2	1 2·2	11·5	11·5	24	25 8	75 12		
6 ditto Light	1 8	11·2	11·5	11·5	24	24 12	64		
3 ditto Heavy	1	9·7	9·0	9·0	30	21 6	53 14		
3 ditto Light			9·0	9·0					
1 ditto Ammuzette. .	6	8·5	6·3	6·3					
Howitzers. Iron. 10-Inch	7	1 1·8	1 3·8	9·7	8	28 2	79 2		
Howitzers. Iron. 8 ditto.	4	1 1·7	1 1·2	7·0	14	28 2	80 10		
Howitzers. Brass. 24-Pounder	2 8	1 0·2	10·0	6·3					
Howitzers. Brass. 12 ditto.	1 4	10·8	8·5	5·8					
Howitzers. Brass. 5½-Inch	2	10·3	5·9	3·8	20	28 2	71 2		
Howitzers. Brass. 4⅗ ditto.	8	7·6	5·0	3·0	40	24	46 8		
Carronades. 68-Pounder	5 10	1 2·3	1 9·0	1 9·0					
Carronades. 42 ditto.	3 8	1 5·0	1 7·1	1 7·1					
Carronades. 32 ditto.	2 10	1 6·0	1 5·5	1 5·5					
Carronades. 24 ditto.	2	11·0	1 3·9	1 3·9					
Carronades. 18 di to.	1 8	10·0	1 1·8	1 1·8					
Carronades. 12 ditto.	1	8·8	1 1·2	1 1·2					
Carronades. 6 ditto.	12	7·5	10·1	10·1					

The dimensions in this table include an allowance for the seams, which vary in breadth from one inch to eight-tenths of an inch. When the two circumferences are of different lengths, each cartridge is made of two pieces, and the dimensions given are for one piece only.

Table, shewing the Number of Cartridges of each Nature for Guns and Carronades, packed in Lead-lined Barrels and Cases.

	NATURE OF ORDNANCE.	Charge of Powder. lb.	Charge of Powder. oz.	Barrels or Cases. Whole. Cartridges in each.	Whole. Weight. Empty. lb.	Whole. Weight. Empty. oz.	Whole. Weight. Filled. lb.	Whole. Weight. Filled. oz.	Half. Cartridges in each.	Half. Weight. Empty. lb.	Half. Weight. Empty. oz.	Half. Weight. Filled. lb.	Half. Weight. Filled. oz.	Tonnage. cwt. qr. lb.
Guns (Barrels). Full Charges.	32-Pounder	10	11	7			125	1	3			57		
	24 ditto	8		10			130	4	5			69	15	
	18 ditto	6		13			128	12	6			66	1	
	12 ditto	4		21			134	12	10			70	1	
	9 ditto	3		28			134	12	14			72	1	
	6 ditto	2		40			130	12	20			70	1	
Guns (Barrels). Reduced Chgs.	32 ditto	8		8	49	4	114	4	5	29	8	70	2	
	24 ditto	6	4	13			128	4	6			65	2	
	18 ditto	4		18			131	8	9			70	10	
	12 ditto	3		28			134	12	14			72	4	
	9 ditto	2	4	38			136	4	19			71		
	6 ditto	1	8	52			128	12	51			69	4	
Guns (Cases). Full Charges.	32 ditto	10	11	10			167	13	5			88	15	
	24 ditto	8		14			172	4	7			91	8	
	18 ditto	6		19			175	12	9			89	11	
	12 ditto	4		30			180	12	15			95	11	
	9 ditto	3		39			177	12	19			91	11	
	6 ditto	2		58			176	12	29			93	11	
Guns (Cases). Reduced Chgs.	32 ditto	8		14	58	12	172	4	7	34	12	91	12	
	24 ditto	6		19			174	4	9			89	12	
	18 ditto	4	8	24			168	12	12			89	12	
	12 ditto	3		40			180	12	20			95	12	
	9 ditto	2	4	50			173	4	25			92		
	6 ditto	1	8	72			168	12	36			89	12	
Carronades. Cases.	68 ditto	5	10	20			175	4	10			92	13	
	42 ditto	3	8	32			172	4	16			91	5	
	32 ditto	2	10	40	58	12	165	8	20	34	12	88	3	
	24 ditto	2		55			170		27			89	10	
	18 ditto	1	8	72			168	12	36			89	10	
	12 ditto	1		102			162	12	51			86	12	
Carronades. Barrels.	68 ditto	5	10	14			130	12	7			70		
	42 ditto	3	8	22			127	12	11			68	8	
	32 ditto	2	10	30	49	4	139	4	15	29	8	69	8	
	24 ditto	2		38			126	8	19			68	2	
	18 ditto	1	8	57			133	4	27			70	10	
	12 ditto	1		73			125	12	36			66	4	

The following Proportions of Materials are required to complete One Hundred Flannel, or Four Hundred and Eighty Paper Cartridges, of each Nature.

Nature of Ordnance.		Cartridges. Flannel. Powder.	Flannel. Serge.	Flannel. Worsted.	Paper. Powder.	Paper. Common Cartridge.	Paper. Alum.	Paper. Size.	Paper. Line (Sugar-loaf).
		cwt. qr. lb.	yds. ft. in.	lbs. oz. dr.	cwt. qr. lb.	Rhs.	lb. oz.	lb. oz.	oz. drs.
Guns. Full Charges.	68-Pounder	6 1	29	4					
	42 ditto	12 2	60	4	60	1	6	196	2 12
	32 ditto	9 2 5	58	4	45 3 7	1	6	196	2 12
	24 ditto	7 16	50	3 8	34 1 4	1	5 8	140	2 8
	18 ditto	5 1 12	30	3	25 2 4	1	5	112	2 4
	12 ditto	3 2 8	23	2	17 16	½	4	112	2
	9 ditto	2 2 20	20	2	12 3 12	½	3 12	99 12	1 12
	6 ditto	1 3 4	16	1 8	8 2 8	½	3 8	81	1 12
	3 ditto	3 16	9	1 4	6 1 20	¼	1 12	40 8	1 8
	1 ditto	1 10	7	1					
Guns. Reduced Charges.	68-Pounder								
	42 ditto								
	32 ditto	7 — 16	45	3 8					
	24 ditto	5 2 9	46	3					
	18 ditto	3 2 8	23	2					
	12 ditto	2 2 20	18	2					
	9 ditto	2 — 1	15	1 8					
	6 ditto	1 1 10	10 2 6	1 8					
	3 ditto	2 19	8	1					
	1 ditto								
Howitzers. Iron.	10-Inch	6 1	39 1 6	3					
	8 ditto	3 2 8	26 1 6	3					
Howitzers. Brass.	24-Pounder	2 26	24 1 6	2					
	12 ditto	1 13	15	2					
	5½-Inch	1 3 4	9	1					
	4⅖ ditto	1 22	5 1 6	1					
Carronades.	68-Pounder	5 3	30	2 8					
	42 ditto	3 14	24	2 4					
	32 ditto	2 1 11	22	2					
	24 ditto	1 3 4	18	2					
	18 ditto	1 1 10	14	1 8					
	12 ditto	3 16	12	1 8					
	6 ditto	2 19							

The above are the only descriptions of paper cartridges in the service, and they are now nearly obsolete.

II.—Cartridges for Small-Arms.

General Table of Small-Arm Cartridges.

Nature of Arm.	Charge for: Service.	Proof.		Exercise.	Number packed in each: Bundle.	Box.	Weight of Box: Empty.		Filled.		Cartridges.	
	drs.	ozs.	drs.	drs.			lbs.	oz.	lbs.	oz.	lbs.	oz.
Musket	6	1	$7\frac{1}{3}$	5	10	1000	12	4	106	3	93	13
Carbine — Common	4	0	15	4	10	1300	12	4	98	3	85	10
Carbine — Musket Bore	$5\frac{1}{2}$	0		$4\frac{1}{2}$	10	1080	12	4	109	10	97	4
Rifle	4	0		4	10	1300	12	4	98	5	85	10
Pistol — Carbine Bore	3	0		3	10	1500	12	4	106	15	94	8
Pistol — Musket do.	$3\frac{1}{2}$	0		3	10	1350	12	4	123	14	111	8

The service charges in the above table are those established by authority; they are, however, too great, and might be advantageously reduced by about one-fourth. They have not been altered since 1775; whilst the strength of the powder has been increased in nearly a two-fold ratio since that period.

Table for Preparing Small-Arm Cartridges.

Nature of Arm.	Dimensions of Formers: Diameter.	Hollow.	Length.	Number in each Sheet.	Dimensions of Papers: Longest side.	Breadth.	Shortest side.	Number made by a Man or Boy, in a Day.
	In.	In.	In.		In.	In.	In.	
Musket	·65	·2	5·25	12	7·15	5·3	3·75	400
Carbine — Common	·59	·18	5·9	16	6·0	5·15	2·6	400
Carbine — Musket Bore	·65	·2	5·25	12	7·15	5·3	3·75	400
Rifle	·59	·18	5·9	16	6·0	5·15	2·6	400
Pistol — Carbine Bore	·59	·18	5·9	16	6·0	5·15	2·6	400
Pistol — Musket do.	·65	·2	5·25	12	7·15	5·3	3·75	400

The shape of the forming papers is that of a right-angled trapezoid, and the perpendicular distance between its two parallel edges is, in the above table, taken as the breadth.

The following Proportions of Materials are required for making One Thousand of each Nature of Small-Arm Cartridges.

DESCRIPTION OF MATERIALS.	Ball.								Blank.				
	Carbine.		Musquet.		Pistol.		Rifle.		Carbine.		Musq.	Pistol.	
	Common.	Musq. Bore.	Common.	With Buck Shot.	Carb. Bore.	Musq. Bore.	With Fustian	Without Fustian.	Common.	Musq. Bore.	Common.	Carb. Bore.	Musq. Bore.
Powder, F.G., lbs. ozs.	15 11	20 8¾	23 8	23 8	11 12½	13 11¾	15 11	15 11	15 11	17 9½	19 9	11 12	11 12
Paper, qrs.shts { Fine white ..	2 21	3 20	3 20	3 20	2 21	3 20	2 21	2 21					
Whited-brown	1 22	1 22	1 22	1 22	1 8	1 22	1 22	1 22					
Blue or Purple									3 20	3 20	3 20	3 3	3 7
Thread, Dutch, lbs. ozs.	3 14	4 15	4 15	4 15	3 14	4 15	3 14	3 14	2 3	2 3	2 3	2 3	2 5
Twine, Packing	1 13	2 8	2 8	2 8	1 8	1 9	1 13	1 13	1 3	1 3	1 3	1 3	1 3
Fustian, patches of....							1000						
Shot-lead, ...lbs. ozs.	50 0	68 15	68 15	68 15	50 0	68 15	45 7½	50 0					
Ditto, Buck, ditto....				24 12									

CASE SHOT.

Weight, Dimensions, &c. of Case Shot for Guns, Howitzers, and Carronades.

NATURE OF ORDNANCE.	Shot.		Tampeons.						Cases.				
			Iron.			Wood.				Depth.			
	Weight.	No. in each.	Thickness	Diameter	Weight.	Thickness	Diameter	Weight.	Circumference.	Between the Clipts.	Total.	Weight.	Total Weight.
	lb.oz.drs.		In.	In.	lb.oz.drs.	In.	In.	lb.oz.drs.	In.	In.	In.	lb.oz.drs.	lb.oz.drs.
Guns. Garrison and Sea Service. 68-Prs...	8		·06	7·6	11	1·9	7·6						
42 do...	8	85	·05	6·45	9	1·52	6·45		21·6	9·0	10·0	1 6	42 15
32 do...	8	66	·05	5·9	7	1·32	5·9		19·8	8·3	9·5	15	33 8
24 do...	8	46	·05	5·3	7	1·29	5·3		18·1	7·6	8·7	9 8	23 8
18 do...	6	46	·05	4·75	4 8	1·2	4·75		16·5	7.35	8·4	9	18 14
12 do...	4	46	.04	4·25	2 8	1·1	4·25		14·4	6·0	7·1	8 8	11 13
9 do...	3	44	·04	4·0	2	1·0	4·0		13·2	5·3	6·3	7	8 8
6 do...	2	40	·04	3·5	1 8	·98	3·5		11·5	4·5	5·6	5	5 12
4 do...	3	28	·04	2·9	1	·86	2·9		9·9	5·9	6·6	6	4
3 do...	1 8	34	·04	2 7	12	·79	2·7		9·1	4·25	4·7	3	3 9

Case Shot.—Continued.

Nature of Ordnance.	Shot. Weight. lb.oz.drs.	Shot. No. in each.	Tampeons. Iron. Thickness In.	Tampeons. Iron. Diameter In.	Tampeons. Iron. Weight. lb.oz.drs.	Tampeons. Wood. Thickness In.	Tampeons. Wood. Diameter In.	Tampeons. Wood. Weight. lb.oz.drs.	Cases. Circumference. In.	Cases. Depth. Between the Clipts. In.	Cases. Depth. Total. In.	Cases. Weight. lb.oz.drs.	Total Weight. lb.oz.drs.
Guns. Field Service. 12-Prs.	2	126	·05	4.25	2 8	1·1	4·25		14·4	7·7	8·8	11	17 6 8
	6 8	41	·05	4·25	2 8	1·1	4·25		14·4	7·63	8·7	13	15 9
9 do.	1 8	126	·05	4·0	2	1·0	4·0		13·2	7·3	8·4	9	12 14
	5	41	·05	4·0	2	1·0	4·0		13·2	7·0	8·0	9 8	13 4
6 do.	1 8	85	·05	3·5	1 8	·98	3·5		11·5	6·7	7·7	8	8 12
	3 4	41	·05	3·5	1 8	·98	3·5		11·5	6·1	7·2	7	9
3 do...	1 8	41	·05	2·7	12	·79	2·7		9·1	4·8	5·8	4	4 5
Howitzers. 10-Inch	8	170	·06	9·7	13				31·7	8·3	9·4	2 1	86 4
8 do.......	2	285	·05	7·6	8 8		7·8		24·8	7·6	8·6	14	35
5½ do.......	2	100	·05	5·3	4	1·29	5·3		18·1	4·5	5·7	7	14
4⅖ do.......	2	55	·04	4·25	2	1·1	4·25		14·4	3·7	4·8	4 8	7 11 8
24-Prs.......	2	140	·05	5·3		1·29	5·3		18·1	5·5	6·5		19 4
12 do.......	2	84	·04	4·25		1·1	4·25		14·4	5·2	6·2		11 13
Carronades. Case. 68-Prs. .	8	90	·06	7·6		1·45	7·6	1 6 4	24.5	7·7	8·9	1 4	46 2
42 do...	8	66	·05	6·45		1·35	6·45	1 12	21.6	7·9	8·9	1 2	32 8 8
32 do...	8	40	·05	5·9		1·0	5·9	7 4	19·3	5·9	7·0	11 4	21 4
24 do...	8	32	·05	5·3		·85	5·3	6 8	17·9	5·8	6·8	10 8	16 1
18 do...	6	31	·05	4·75		·8	4·75	6 6	15·8	5·7	6·6	7 4	12 2
12 do...	4	32	·04	4·25		·75	4·25	4 6	13·8	4·4	5·5	5 12	8 2
Carronades. Grape. 68-Prs...	3	15		7·6		1·45	7·6	1 6 4	24·7		9·2		
42 do...	4	9		6·45		1·35	6·45	1 12	21·3		9·8		
32 do...	3	9		5·9		1·0	5·9	7 4	19·2		9·0		
24 do...	2	9		5·3		·85	5·3	6 8	17·4		7·8		
18 do...	1 8	9		4·75		·8	4·75	6 6	15·8		6·9		
12 do...	1	9		4·25		·75	4·25	4 6	13·9		6·5		

The weights and dimensions of the cases in this table apply to the new pattern case-shot, introduced into the service by Major General Millar. The depth of the old pattern cases is generally four or five-tenths of an inch less than the above. See observations on firing Grape and Case-Shot.

The following are the Proportions of Materials required to complete One Hundred of each Nature of Case-Shot.

Nature of Ordnance.	Shot. Weight. lb.	oz.	drs	Number.	Glazing Sprigs. lb.	oz.	drs.	Tampeons.	Tin Plates * * Single.	* Single.	Solder. lbs.	oz.	Charcoal. Bush	Rosin. lbs.	oz.	Timber, Elm or Alder of sufficient diameter to cut out a Tampeon. yds.	ft.	in.
Guns. Garrison & Sea Service. 68-Prs.																		
42 do.		8		8500		15	8	100	300		12		3	1		5	1	
32 do.		8		6600		13	12	100	200		10		3	1		5		
24 do.		8		4600		12	4	100	200		9		3	1		4	1	
18 do.		6		4600		10	12	100	134		8		$2\frac{1}{2}$		14	4		
12 do.		4		4600		10	12	100		125	7		2		12	3		
9 do.		3		4400		9	4	100		125	6		$1\frac{1}{2}$		12	2	2	
6 do.		2		4000		7	8	100		52	5		$1\frac{1}{2}$		12	2	1	
4 do.		3		2800		6	4	100		52	5		$1\frac{1}{2}$		12	2	1	
3 do.		1	8	3400		6	4	100		37	3		1		6	2	1	

Nature of Ordnance.	Shot. Weight. lb.	oz.	drs	Number.	Glazing Sprigs. lb.	oz.	drs.	Tampeons.	Tin Plates * * Single.	* Single.	Solder. lbs.	oz.	Charcoal. Bush	Rosin. lbs.	oz.	Timber yds.	ft.	in.
Guns. Field Service. 12-Prs		2		12600		10	12	100		125	7		2		12	3		
		6	8	4100		10	12	100		125	7		2		12	3		
9 do.		1	8	12600		9	4	100		118	7		$1\frac{1}{2}$		12	2	2	
		5		4100		9	4	100		118	7		$1\frac{1}{2}$		12	2	2	
6 do.		1	8	8500		7	8	100		118	6		$1\frac{1}{2}$		12	2	1	
		3	4	4100		7	8	100		118	6		$1\frac{1}{2}$		12	2	1	
3 do.		1	8	4100		6	4	100		59	4		1		8	2	1	
Howitzers. 10-Inch		8		17000	2	3		100	300		12		3	1		9		
8 do.		2		28500	1	2	8	100	300		9		$2\frac{1}{2}$		14	7	1	
$5\frac{1}{2}$ do.		2		10000		12	12	100		102	6		$1\frac{1}{2}$		12	5	1	
$4\frac{2}{5}$ do.		2		5500		10	12	100		75	5		$1\frac{1}{2}$		10	4	1	
24-Pounders		2		14000		12	4	100								6		
12 do.		2		8400		10	12	100								4	2	
Carronades. Case. 68-Prs.		8		9000	1	4		100	300		11		3	1		5		
42 do.		8		6600		15	8	100	300		11		3	1		2	2	
32 do.		8		4000		13	12	100	150		9		$2\frac{1}{2}$		14	2	1	6
24 do.		8		3200		12	4	100	150		9		$2\frac{1}{2}$		14	2		6
18 do.		6		3100		10	12	100	134		7		2		12	2		
12 do.		4		3200		9	12	100		75	5		$1\frac{1}{2}$		10	1	1	6
Grape. 68-Prs.	3			1500	1	4		100	300		12		3	1		5		
42 do.	4			900		15	8	100	300		12		3	1		6		
32 do.	3			900		13	12	100	200		10		3	1		2	1	6
24 do.	2			900		12	4	100	200		9		3	1		2		6
18 do.	1	8		900		10	12	100	134		8		$2\frac{1}{2}$		14	2		
12 do.	1			900		9	12	100		125	7		2		12	1	1	6

The preceding calculation applies generally to case-shot with iron or wood tampeons. One of these being fixed on, the other must of course be omitted in any requisition for materials.

CASKS.

It is usual to divide casks into classes or varieties, according to their greater or less degree of buldge, and consequently to compute the content of each by a separate rule adapted to these several circumstances. To enter into all these particulars, in a small work of this kind, would occupy a greater space than the importance of the subject would justify; we shall, therefore, confine ourselves to one general rule, which will give the content, of each variety, sufficiently near the truth for all practical purposes.

To find the Content of a Cask.

To the area of the head add twice the area at the bung; multiply that sum by the length, and take one-third of the product for the content.

That is, $\overline{2D^2 + d^2} \times \frac{1}{3} L n =$ the content of the cask.

Where D is the diameter at the bung; d, the diameter at the head; L, the length of the cask; and $n = \cdot 7854$.

Example. The length of a cask being 40 inches, and the head and bung diameters 18 and 30 inches respectively, what will be its content?

Here, $\overline{2 D^2 + d^2} \times \frac{1}{3} L n = \overline{2 \times 30^2 + 18^2} \times$ $\cdot 2618 \times 40 = 2124 \times 10\cdot 472 = 22242\cdot 528$ cubic inches. The content required.

See the word Bridges.

CHAMBERS.

It is not found by experience that chambers have any sensible effect on the velocity of shot, unless in the largest description of ordnance; neither is it found that the form of them is very material. A small cylinder is as good as any, though mathematical speculations may shew a preference of one form over another. The chief point to be attended to in practice, is, to have the chamber of a capacity just sufficient to contain the powder, and no more; so that the shell may lie close to the charge, and that its axis be in the prolongation of that of the bore, in order that the centre of the shell and the axis of the charge may exactly coincide.

Experiments were made at Woolwich in 1787 and 1789, with an 8-inch mortar, and four shifting chambers, to ascertain which form gives the longest range.

The chambers were all of the same capacity, viz.—63·7 cubic inches, and contained each two pounds of powder.

Their forms were—

1. The common conical chamber, with hemispherical bottom

2. The same reversed.

3. The cylindrical chamber, with hemispherical bottom.

4. The spheric chamber.

The ranges were a medium of six rounds; from them it appears that when the spheric chamber is filled with powder, it has the advantage in point of range. But when smaller charges are used, its ranges are found to be shorter than those of the other forms. The conical (No. 1) chamber gives the longest range under all other circumstances.

Other experiments have since been made, and the parabolic chamber and lodgement were preferred.

To find the Content of a Cylindrical Chamber.

1. Multiply the area of the base by the depth, for the content of the cylindrical part.

2. Take half the product of the cube of the diameter and the decimal ·5236 for the content of the hemispherical part.

Then, the sum of these two contents will be the content of the whole chamber.

Example. The depth of a chamber being 12·109 inches, and its diameter 4·218 inches, required its content?

Here, $(4{\cdot}218)^2 \times 0{\cdot}7854 = 13{\cdot}671936$ square inches. The area of the base.

Then, by the rule,

13·671936 × 10 = 136·71936 cubic inches. The content of the cylindrical part.

And, $\frac{(4 \cdot 218)^3 \times \cdot 5236}{2} = 17 \cdot 43814$ cubic inches. The content of the hemispherical part.

Whence, 136·71936 + 17·43814 = 154·1575 cubic inches. The content of the chamber.

To find the Content of a Gomer, or other Conical Chamber.

1. Add into one sum the areas of the two ends, and the mean proportional between them, and take one-third of this sum for a mean area; which mean area being multiplied by the depth of the chamber, minus the depth of the spherical segment, will give the content of the conical part.

2. To three times the square of the radius of the segment's base, add the square of its depth; then multiply that sum by the depth, and the product by the decimal ·5236 for the content of the spherical part.

Then, the sum of the contents of these two parts will be the content of the whole chamber.

Example. The superior and inferior diameters of a Gomer chamber being 8 and 4 inches, and the areas of its two ends 50·286 and 12·571 square inches respec-

tively, the depth of the spherical part 1·5 inches, and of the whole chamber 20 inches, required its content?

Here, $\sqrt{50{\cdot}286 \times 12{\cdot}571} = 25{\cdot}142$ square inches. The mean proportional between the two ends.

And, $\frac{50{\cdot}286 + 25{\cdot}142 + 12{\cdot}571}{3} = 29{\cdot}333$ square inches. The mean area of the conical part.

Then, $29{\cdot}333 \times (20 - 1{\cdot}5) = 542{\cdot}66$ cubic inches. The content of the conical part.

Again, $(48 + 2{\cdot}25) \times 1{\cdot}5 \times {\cdot}5236 = 39.466$ cubic inches. The content of the spherical part.

Whence, $39{\cdot}466 + 542{\cdot}66 = 582{\cdot}126$ cubic inches. The content of the chamber.

To find the Quantity of Powder a given Chamber will Contain.

Divide the content of the chamber, in inches, by 30, and the quotient will be the quantity of powder, in pounds.

Example. The content of a chamber being 135·9 cubic inches, required the quantity of powder it will contain?

Here, $\frac{135{\cdot}9}{30} = 4{\cdot}53$ lbs. The quantity of powder required.

CHARCOAL.

The charcoal used as an ingredient in the manufacture of gunpowder, is defined to be a body composed *of a combustible matter, and of the dense earthy particles contained in vegetables.* In making charcoal, the vegetables are burned in such a manner that they do not inflame, and then the combustible matter unites itself intimately with the most dense earthy particles. Charcoal can only be decomposed by fire, which, at the beginning of the ignition, separates the combustible matter from the earthy particles, which are then termed *cinders.*

When charcoal is exposed in the open air to a sufficient degree of heat, its property is to burn and be consumed. It sometimes emits a little blue flame, but more frequently sparkles, and becomes red without emitting any flame. If, in this state, it be agitated by the wind, it appears of a more lively and brilliant red in proportion to the degree of agitation it experiences, and is sooner reduced to cinders. From this property it enters into the composition of gunpowder.

Generally speaking, charcoal appears red only when a greater degree of heat is applied to it than will burn sulphur;—the propagation of the ignited motion, and its total consumption, are effected more slowly than in sulphur. These effects differ according to the quality of the charcoal;—that which is the lightest, or which contains the least quantity of the dense earthy particles, takes fire and is consumed quickest.

The more the air is rarefied, the less easily charcoal burns, and the greater the degree of fire requisite to keep it red-hot.

See the word GUNPOWDER.

CHARGES.

The service charges of powder for guns vary from one-third to one-fourth, or even less, and for carronades, from one-eighth to one-sixteenth of the shot's weight; and, indeed, in most ordinary cases of service, this proportion is too high for the intended execution, especially for naval ordnance. Experience has proved, that if the charges of ship-guns were still further reduced to one-fourth, or even one-fifth of the shot's weight, it would be a considerable advantage not only by the saving of ammunition it would produce, but by keeping the guns cooler and quieter, and at the same time more effectually injuring the vessels of the enemy; for with the present charges the guns are over-heated, and their tackle and furniture strained, and this only to render the ball less efficacious than it would prove if impelled by a smaller charge.

Indeed, in breaching walls which cannot be penetrated by a single shot from any piece of ordnance whatever, the velocity of the ball, how much soever augmented, still produces a proportionate effect by augmenting the depth to which it penetrates. But the sides of the strongest ships,—the greater part

of their timbers being of a limited thickness,—are insufficient to resist the generality of cannon shot fired at a reasonable distance, even with a less charge than is here proposed. And it is matter of experiment, that a ball, which can but just pass through a piece of timber, and loses almost all its motion thereby, has a much better chance of rending and fracturing it, than if it passed through with a much greater velocity.

The celebrated Benjamin Robins, from whose works the above remarks are principally extracted, further observes, that the charge of a piece of ordnance is not to be determined by the greatest velocity that may be produced, but that it should be such a quantity of powder as will produce the least velocity necessary to the purpose in view; and if the windage be moderate, as it is at present, no field gun should ever be loaded with more than one-sixth, or at the utmost one-fifth of the shot's weight in powder; nor should the charge of any battering gun exceed one-third of the weight of its shot.

Dr. Hutton, in his paper in the Philosophical Transactions for 1778, observes, that different charges of powder, with the same weight of ball, produce different velocities in the ball, which are in the subduplicate ratio of the weights of the powder; and when the weight of the powder is the same, and that of the ball varied, the velocity produced is in the reciprocal sub-duplicate ratio of the weight of the ball:—which is agreeable both to theory and practice.

But this is on a supposition that the gun is of an indefinite length; whereas, on account of the limited length of guns, there is some variation from this law in practice, as well as in theory; in consequence of which, it appears, that the velocity of the ball increases with the charge only to a certain point, which is peculiar to each particular gun, where the velocity is greatest, and that by farther increasing the charge, the velocity farther diminishes, till the bore is quite full of powder. By an easy fluxionary process it is found that, calling the length of the gun's bore b, the length of the charge, producing the greatest velocity, ought to be $\frac{b}{2 \cdot 718281828}$, or about three-eighths of the length of the bore. But, for several reasons, in practice the length of the charge producing the greatest velocity, falls short of that above-mentioned, and the more so in proportion as the gun is longer. Dr. Hutton found, from many experiments, that the length of the charge, in terms of the bore, producing the greatest velocity in guns of various lengths of bore from 15 to 40 calibres, was as follows:—

Length of Bore.	Length of Charge.
15	$\frac{3}{10}$
20	$\frac{3}{12}$
30	$\frac{3}{16}$
40	$\frac{3}{20}$

The following are the Established Charges for Guns, Howitzers, and Carronades.

Nature of Ordnance.			Charges. Proof. lb.	Proof. oz.	Service. lb.	Service. oz.	Saluting. lb.	Saluting. oz.	Scaling. lb.	Scaling. oz.
Guns.	Iron.	130-Pounder, or 10-Inch Gun. 68-Pounder...	14		7				2	
		42 ditto.......	25		14		10	8	3	
		32 ditto.......	21	8	10	11	8		2	12
		24 ditto.......	18		8		6		2	
		18 ditto.......	15		6		4		1	8
		12 ditto.......	12		4		3		1	
		9 ditto.......	9		3		2			12
		6 ditto.......	6		2		2			8
	Brass.	12 ditto Medium	5		4		3			12
		12 ditto Light..	4		3		3			8
		9 ditto.......	3	8	3					
		6 ditto.......	3		2		2			8
		6 ditto.......	2		2		2			8
		6 ditto, 5 feet.	2		1	8	1			4
		3 ditto.......	1	8	1		1			4
		3 ditto.......	1		1			8		2
		1 ditto.......	1			6		6		2
Howitzers.	Iron.	10-Inch........	14		7					
		8 ditto.......	8		4					
	Brass.	24-Pounder.....	3		2	8				
		12 ditto.......	1	8	1	4				
		$5\frac{1}{2}$-Inch........	3		2					
		$4\frac{2}{5}$ ditto......		8		8				
Carronades.		68-Pounder.........	13		5	10	5	10	2	
		42 ditto...........	9		3	8	3	8	1	8
		32 ditto...........	8		2	10	2	10	1	6
		24 ditto...........	6		2		2		1	
		18 ditto...........	4		1	8	1	8		12
		12 ditto...........	3		1		1			8
		6 ditto...........	1	8		12		12		6

CHEVAUX-DE-FRIZE.

Weight, Dimensions, &c. of Chevaux-De-Frize.

					ft.	in.	Weight.
Old Pattern (Wood).	Cavalry.	Barrel....	Length		9	5	30 lbs.
			Square		0	4	
		Spears, 20..	Length		6	0	25
			Total Weight....				55
	Infantry.........		Length.......		5	4..	6lb. 8 oz.
New Pattern, (Iron.)		Barrel....	Length		6	0	19 lbs.
			Diam.		0	4	
		Spears, 12..	Length		5	9	46 lbs.
			Total Weight....				65 lbs.

COMPOSITION.

For the composition of Fuzes, Port-fires, &c. see those words.

All dry compositions must be well mixed, first, by the hands, and then passed several times through fine hair sieves, that the ingredients may be thoroughly incorporated.

In mixing compositions which require fire, the greatest precautions are necessary, particularly in those of which gunpowder forms a part. The dry parts of the composition may, in general, be mixed together first, and put by degrees into the cauldron,

while the other ingredients are fluid, the liquid being well stirred all the time of putting in. When the dry ingredients are inflammable, the cauldron must not only be taken off the fire, previously to putting them into it, but the bottom must be dipped in water, to prevent the possibility of accidents.

Royal Laboratory.

CONVOYS.

A waggon with four horses occupies about sixteen paces; a mile will, therefore, hold a train of about 105 waggons; but, allowing a short distance between each waggon in travelling, a mile may be said to contain 100 waggons.

Waggons in convoy may travel from one to two miles an hour, according to the state of the roads, and other circumstances. A great object in the marching of a convoy is to preserve the horses, as much as possible, from fatigue. For this purpose, if the convoy amount to many hundred waggons, they must be divided into divisions of not more than 500 each. Should it consist of thousands, it will be advisable to divide it into grand divisions, and then again into subdivisions of 500 each. By this means, and by calculating the time of departure, according to the following rules, each division may remain at rest till just before its time of movement, and the necessity will thus be prevented of the latter part of a large

convoy being harassed for a considerable time before its turn to move.

To find the Time in which any Number of Waggons may be driven Off.

Say,
As the number of waggons which one mile will hold,
Is to the number to be driven off;
So is the time of travelling one mile,
To the time of driving off.

Example.—Suppose 240 waggons to be in convoy, what time will elapse between the driving off of the first and last waggon?

Here a mile is supposed to hold 100 waggons, and each waggon to be able to travel two miles in an hour. Therefore, say,

	Waggons.		Waggons.		Min.		Hour.	Min.
As	100	:	240	: :	30	:	1	12.

The time of drawing off.

To find the Time which a Convoy will require to travel any given Distance.

First, by the preceding rule, find the time required for driving off, and this time, plus the time which any one of the waggons occupies in travelling the distance, will be the time required.

Example. Required the time which a convoy of 240 waggons will require to travel 30 miles, supposing it, when once in motion, to travel at the rate of two miles an hour?

Hour. Min.
First—1 12 = time of driving off, by the preceding example.

And,
Miles. Hour. Miles Hours.
As 2 : 1 :: 30 : 15. The time one waggon will take to travel the distance.

Hour. Min. Hours. Hours. Min.
Then, by the rule, 1 12 + 15 = 16 12. The time which the convoy will occupy in travelling a distance of 30 miles.

The different divisions of the convoy should be numbered, and obliged each day to change the order of their marching.

Whenever the progress of a train of waggons is arrested by the breaking down of one of them, or other delay, all the waggons, in rear of the stoppage, should immediately drive up into the first open space, to as great a number as it will hold. This will keep the convoy together, and better under the care of the escort.

The escort should be divided into front, centre, and rear guards; besides the divisions for the flanks, which

should never be beyond musquet shot, or at most 400 yards from each other.

TEMPLEHOFT.

CORDAGE.

Ropes, cables, and all other descriptions of cordage are distinguished by their circumferences;—thus, a two-inch rope means a rope of two inches in circumference.

The weights, dimensions, &c. of the principal descriptions of cordage, are given in the annexed tables. The following rule may, however, be found useful in computing the weights of any intermediate descriptions.

To find the Weight of a Rope.

Multiply the length in fathoms by the square of the circumference, and divide the product by 480 for the weight in cwts.

M. Duhamel, from a series of experiments on the relative strength of tarred and white or untarred cordage, has obtained the following results.

1. That untarred cordage, in constant use, is one-third more durable than the same cordage when tarred.

2. That white cordage retains its strength for a much longer period when laid up in store. And,

3. That white cordage resists the ordinary injuries

of the weather one-fourth longer than that which is tarred.

These results of direct experiments have been confirmed by the observations of seamen; but it has been invariably found that the white cordage is weaker than the tarred, when it is exposed to be wet and dry alternately. Tarred cordage is chiefly useful for cables and ground tackle, which are constantly soaked in water; and cordage superficially tarred, is found to be stronger than such as is thoroughly tarred, and it resists better the alternations of dryness and wetness.

In 1805 an experiment was tried, to determine whether or not any advantage would be derived from employing teak, in preference to common, tar; for this purpose, two three-inch ropes were prepared from the same yarns, and they were placed in the same store till 1807, when their strengths were found to be as follow:—

The common tarred broke with 3848 lbs.
The teak tarred broke with 5980 lbs.

Consequently, by using teak tar, an advantage, with regard to strength, was obtained in the proportion of three to two.

To find the Strength of a Rope, or the Weight it will Support.

Square the circumference, and divide by 5 for the number of tons which it will bear suspended from it.

The following Tables, compiled from Actual Experiments, contain the Lengths, Weights, &c. of the Principal Ropes, Hawsers, and Cables.

I.—Weight, Dimensions, &c. of Ropes (Common made).

Length.	Of 1 Inch or 9 Threads.			Of 2 Inch or 33 Threads.			Of 3 Inch or 75 Threads.			Of 4 Inch or 132 Threads			Of 5 Inch or 204 Threads			Of 6 Inch or 300 Threads			Of 7 Inch or 403 Threads		
Fathoms.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.
1									1			2			4			6			8
2						1			3			5			8			12			17
3			1			2			5			8			13			19			26
4			1			2			6			11			17			25		1	7
5			2			3			8			14			21		1	4		1	15
6			2			4			10			17			26		1	10		1	24
7			3			5			12			19		1	2		1	17		2	5
8			3			5			13			22		1	7		1	23		2	14
9			4			6			15			25		1	11		2	2		2	23
10			4			7			17		1			1	15		2	8		3	3
15			6			10			25		1	14		2	8		3	12	1		18
20			9			14		1	6		2			3	3	1		17	1	2	7
25			11			17		1	14		2	14		3	24	1	1	21	1	3	22
30			14			22		1	23		3	1	1		19	1	2	25	2	1	11
35			16			25		2	3		3	16	1	1	12	1	3	1	2	2	26
40			19		1	1		2	12	1		1	1	2	7	2	1	6	3		15
45			21		1	4		2	20	1		15	1	3		2	2	10	3	2	2
50			23		1	9		3	1	1	1	1	1	3	23	2	3	14	3	3	18
55			25		1	13		3	9	1	1	15	2		17	2	3	18	4	1	6
60		1			1	16		3	18	1	2	2	2	1	11	3	1	23	4	2	22
65		1	2		1	19		3	26	1	2	16	2	2	4	3	2	27	5		10
70		1	5		1	24	1		7	1	3	2	2	2	26	4		3	5	1	26
75		1	7		1	27	1		15	1	3	16	2	3	19	4	1	7	5	3	2
80		1	10		2	3	1		24	2		2	3		14	4	2	12	6	1	2
85		1	12		2	6	1	1	4	2		17	3	1	7	4	3	16	6	2	18
90		1	14		2	11	1	1	13	2	1	3	3	2	2	5		20	7		6
95		1	16		2	15	1	1	21	2	1	18	3	2	23	5	1	24	7	1	22
100		1	19		2	18	1	2	2	2	2	3	3	3	18	5	3	1	7	3	9
105		1	21		2	21	1	2	10	2	2	18	4		14	5		5	8		24
110		1	23		2	24	1	2	18	2	3	6	4	1	12	5	1	9	8	2	11
115		1	25		2	27	1	2	27	3			4	2	5	5	2	13	8	3	27
120		1	27		3	5	1	3	9	3		5	4	2	26	6	3	19	9	1	19
122		2	2		3	7	1	3	12	3		10	4	3	3	7		3	9	2	7

II.—*Weight, Dimensions, &c. of Hawsers* (Machine made).

Length.	Of 4 Inches, or 108 Threads			Of 5 Inches, or 156 Threads			Of 6 Inches, or 228 Threads			Of 7 Inches, or 312 Threads			Of 8 Inches, or 408 Threads			Of 9 Inches, or 516 Threads			Of 10 Inches, or 648 Threads		
Fathoms.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.
1			3			5			8			11			14			18			22
2			7			11			16			22		1			1	8		1	17
3			11			16			24		1	5		1	15		1	26		2	12
4			15			22		1	4		1	16		2	1		2	17		3	7
5			19			27		1	12		1	27		2	16		3	17	1		2
6			22		1	5		1	20		2	10		3	2		3	25	1		25
7			26		1	10		2			2	21		3	17	1		15	1	1	20
8		1	2		1	16		2	8		3	4	1		3	1	1	16	1	2	15
9		1	6		1	21		2	16		3	15	1		17	1	1	24	1	3	10
10		1	10		1	27		2	24		3	26	1	1	4	1	2	14	2		5
15		2	1		2	26	1		8	1	1	25	1	3	20	2	2	3	3		7
20		2	20		3	26	1	1	21	1	3	24	2	2	8	3	1	1	4		10
25		3	11	1		25	1	3	5	2	1	23	3		24	4		18	5		12
30	1		3	1	1	25	2		18	2	3	23	3	3	13	4	3	15	6		16
35	1		22	1	2	24	2	2	2	3	1	22	4	2	1	5	3	4	7		18
40	1	1	12	1	3	24	2	3	14	3	3	21	5		17	6	2	2	8		21
45	1	2	3	2		24	3		26	4	1	20	5	3	5	7	1	19	9		23
50	1	2	23	2	1	24	3	2	11	4	3	20	6	1	21	8		17	10		26
55	1	3	14	2	2	23	3	3	23	5	1	19	7		9	9		6	11	1	
60	2		5	2	3	23	4	1	8	5	3	18	7	2	26	9	3	3	12	1	4
65	2		19	3		23	4	2	20	6	1	17	8	1	14	10	2	20	13	1	6
70	2	1	5	3	1	2	5		4	6	3	17	9		2	11	1	18	14	1	9
75	2	1	19	3	2	1	5	1	16	7	1	16	9	2	18	12	1	7	15	1	8
80	2	2	25	3	3	21	5	3	1	7	3	15	10	1	7	13		5	16	1	15
85	2	3	16	4		20	6		13	8	1	14	10	3	23	13	3	22	17	1	17
90	3		8	4	1	20	6	1	26	8	3	13	11	2	11	14	2	19	18	1	20
95	3		27	4	2	19	6	3	10	9	1	12	12		27	15	2	8	19	1	22
100	3	1	18	4	3	20	7		23	9	3	12	12	3	16	16	1	6	20	1	25
105	3	2	9	5		19	7	2	7	10	1	11	13	2	4	17		23	21	1	27
110	3	3		5	1	18	7	3	19	10	3	10	14		20	18		12	22	2	1
113	3	3	12	5	2	8	8		16	11		16	14	2	8	18	1	20	23		16

III.—*Weight, Dimensions, &c. of Cables* (Machine made).

Length.	Of 7 Inches, or 252 Threads			Of 8 Inches, or 324 Threads			Of 9 Inches, or 432 Threads			Of 10 Inches or 504 Threads			Of 11 Inches or 612 Threads			Of 12 Inches or 756 Threads			Of 13 Inches or 864 Threads		
Fathoms.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.	cwts.	qrs.	lbs.	cwts	qrs.	lbs.
1			9			12			17			19			24		1	1		1	6
2			19			25		1	6		1	11		1	20		2	3		2	12
3		1	1		1	10		1	23		2	3		2	16		3	5		3	18
4		1	11		1	25		2	12		2	23		3	12	1		7	1		24
5		1	21		2	8		3	1		3	15	1		9	1	1	9	1	2	3
6		2	3		2	20		3	18	1		7	1	1	5	1	2	11	1	3	9
7		2	13		3	5	1		7	1		27	1	2	1	1	3	13	2		15
8		2	23		3	18	1		24	1	1	19	1	2	25	2		15	2	1	21
9		3	5	1		3	1	1	13	1	2	11	1	3	22	2	1	17	2	3	27
10		3	15	1		16	1	2	3	1	3	3	2		18	2	2	19	3		6
15	1	1	9	1	2	24	2	1	4	2	2	19	3		27	4			4	2	9
20	1	3	3	2	1	4	3		6	3	2	7	4	1	8	5	1	10	6		12
25	2		25	2	3	12	3	3	7	4	1	22	5	1	17	6	2	20	7	2	15
30	2	2	19	3	1	20	4	2	9	5	1	10	6	1	27	8		2	9		18
35	3		13	4			5	1	11	6		16	7	2	8	9	1	11	10	2	21
40	3	2	7	4	2	9	6		12	7		14	8	2	17	10	2	21	12		24
45	4		1	5		7	6	3	13	8		2	9	2	26	12		3	13	2	27
50	4	1	23	5	2	5	7	2	15	8	3	18	10	3	7	13	1	13	15	1	2
55	4	3	16	6		23	8	1	16	9	1	5	11	3	11	14	2	27	16	3	5
60	5	1	10	6	3	13	9		18	10	2	21	12	3	26	16		4	18	1	9
65	5	3	2	7	1	21	9	3	19	11	2	9	14		7	17	1	13	19	3	12
70	6		26	8		2	10	2	21	12	1	25	15		16	18	2	23	21	1	15
75	6	2	20	8	2	10	11	1	22	13	1	12	16		21	20		5	22	3	17
80	7		14	9		18	12		24	14	1		17	1	7	21	1	15	24	1	21
85	7	2	8	9	2	26	12	3	25	15		16	18	1	16	22		24	25	3	21
90	8		2	10	1	6	13	2	27	16		4	19	1	25	24		6	27	1	27
95	8	1	24	10	3	14	14			16	3	20	20	2	6	25	1	16	29		2
100	8	3	18	11	1	23	15	1	2	17	3	8	21	2	15	26	2	26	30	2	5
101	9			11	2	8	15	1	20	18			21	3	12	27			30	3	12

DISPART.

The dispart of a gun is the difference between the semi-diameter of the gun at the base-ring, and at the swell of the muzzle. But if the gun have a projection on the upper part of its muzzle, as is the case in some recent constructions; then the dispart is the difference between the semi-diameter at the base-ring and that at the muzzle, plus the height of the projection.

Table shewing the Dispart, Length of Tangent for the First Degree, and the Diameter at the Base-ring and at the Swell of the Muzzle of every Gun at present in the Service.

Nature of Ordnance.			Dispart.	Diameter of the Base Ring.	Diameter of the Muzzle	Tangent.
			Inches.	Inches.	Inches.	Inches
Brass.	12-Prs.	Med. 6 ft, 6 in.	1·63	13·83	10·57	1·372
Brass.	12-Prs.	Light... 5 ..	1·04	12·73	10·65	1·049
Brass.	9 do.	.... 5 ..	1·05	12·6	9·6	1·247
Brass.	6 do.	7 feet 0 inches	1·36	11·55	8·83	1·467
Brass.	6 do.	6 do........	1·21	10·64	8·22	1 257
Brass.	6 do.	5 do........	1·0275	9·625	7·57	1·048
Brass.	3 do.	6 feet 0 inches	·905	8·75	6·93	1·257
Brass.	3 do.	4 do........	·815	7·64	6·01	·838
Brass.	3 do.	3 do.	·925	7·65	5·8	·629
Brass.	1 do.	..5 do........	·73	6·27	4·81	1·048

Dispart, Length of Tangent, &c.—
(Continued.)

	Nature of Ordnance.		Dispart.	Diameter of the Base Ring.	Diameter of the Muzzle	Tangent.
			Inches.	Inches.	Inches.	Inches
Iron.	10 Inch Gun, 7 feet 6 in.		2·215	23·75	19·32	1·571
	68-Pounder..6 do. 6 do.		2·4	22·8	18·0	1·406
	42 Ditto....9 do. 6 do.		3·88	25·6	17·84	1·894
	32 do.	9 feet 6 inches	2·895	22·24	16·45	1·894
		8 do 0 do..	3·24	22·43	15·95	1·676
	24 do.	9 do 6 do..	2·615	20·93	15·7	1·894
		9 do 0 do..	2·735	20·93	15·46	1·886
		8 do 0 do..	2·43	20·96	16·1	1·676
		7 do 6 do..	3·13	20·96	14·7	1·475
	18 do.	9 do 0 do..	2·665	19·68	14·25	1·886
		8 do 0 do..	2·465	19·66	14·73	1·676
	12 do.	9 do 0 do..	1·823	17·73	14·084	1·886
		8 do 6 do..	2·5725	17·77	12·625	1·685
		7 do 6 do..	2·3295	17·86	13·201	1·475
	9 do.	9 do 0 do..	2·23	16·7	12·24	1·886
		8 do 6 do..	2·575	16·65	11·5	1·685
		7 do 6 do..	2·2935	16·82	12·233	1·475
		7 do 0 do..	2·1	16·44	12·24	1·467
	6 do.	8 do 6 do..	2·14	15·0	10·72	1·685
		8 do 0 do..	2·5175	15·01	10·975	1·676
		7 do 0 do..	2·2725	15·02	10·475	1·475
		7 do 0 do..	2·095	15·0	10·81	1·467
		6 do 6 do..	1·975	15·03	11·08	1·266
		6 do 0 do..	1·8	15·06	11·46	1·257

DISTANCES.

The accurate determination of the heights and distances of objects being of the utmost importance in a variety of military operations, the problems for their attainment should consequently be certain, simple, and expeditious.

In all problems for this purpose, the distances or altitudes are considered as accessible or inaccessible. Accessible distances are measured by applying to them a certain determinate standard, as an inch, a foot, or a yard; but inaccessible distances can only be ascertained by taking angles, or by some such like method drawn from the principles of geometry.

When instruments are used to measure the magnitude of the angles, the unknown quantities are computed trigonometrically. In the other methods, they are computed on the principles of similar triangles, or some other simple geometrical property, without any regard to the measure of the angles.

The instruments usually employed for measuring angles in the field are the pocket compass and sextant. These instruments cannot, however, at all times be procured; but the following mechanical problems, if properly applied, will, to a certain extent, render an officer independent of them.

HEIGHTS.

I. By the Shadow of the Object.

Set up vertically a staff of known length, and mea-

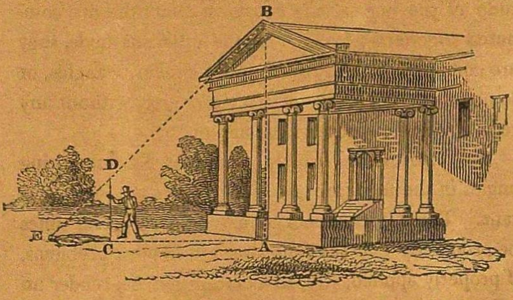
sure the length of its shadow upon a horizontal or other plane; measure also the length of the shadow of the object of which the altitude is required.

Then, by the property of similar triangles;—Say,

As the length of the shadow of the staff,
Is to the altitude of the staff;
So is the length of the shadow of the object,
To the altitude of the object.

II. When there is no Shadow.

Let C D be a staff equal in length to the height of the observer's eye, and let it be set up at C, at such a dis-



tance from the foot of the required altitude, that the observer, having laid himself upon his back, with his feet against the bottom of the stick, may see the tops of D and B of the staff and object appear in the same line.

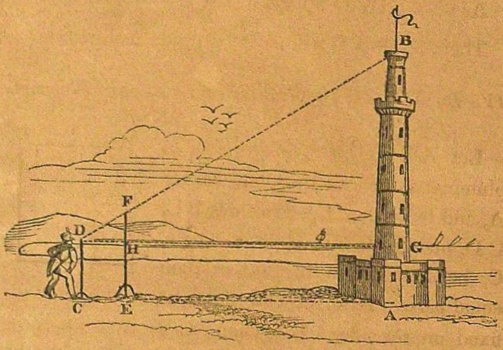
Then, by similar triangles, A E is equal to A B, because, by construction, C E is made equal to C D.

Or, the stick may be of any convenient length, for the distance from its foot to the eye of the observer will always be in the same proportion to its height, as the whole distance is to the altitude of the object required.

III. By Means of Two Staves of Unequal Lengths.

Let two staves, one 6 feet and the other 4 feet long, be placed upon horizontal, circular, or square feet, on which each may stand steadily.

Then, let A B be the object, as a tower or steeple,



of which the altitude is required, and C A a horizontal plane passing through its base.

Also, let C D, E F, the two rods, be placed with their bases in one and the same line C A, passing through A, the foot of the object; and let them be moved nearer to, or farther from, each other, until the summit B of the object is seen in the same line as D and F, the tops of the rods.

Then, by the principle of similar triangles, it will be,

As D H (= C E) : F H : : D G (= C A) : B G.

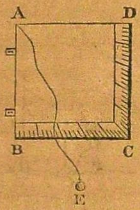
To which add A G = C D, for the whole height A B.

Thus, supposing C E to be 6 feet, F H 2 feet, and C A 150 feet, the proportion will be,

As 6 : 2 : : 150 : 50 feet.

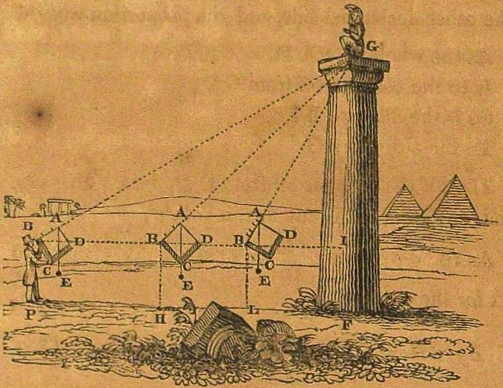
Then, 50 + C D will be the altitude required.

IV. By Means of the Geometrical Square and Plummet.



Let A B C D be a square, A E a plummet suspended from one corner A, and let each of the two sides, B C, C D, meeting in the opposite angle, C, be divided into 10, 100, or 1000 equal parts. Also, let two sights be fixed on the side, A B. Then it is evident, that, in taking any altitude F G with the square, the plummet will always cut off from it a triangle similar to that formed by the base line B I, the

perpendicular I G, and the line of sight B G, of the object.



Consequently, if G B I be an angle of 45 degrees, the plumb line will pass through the opposite angle, C, of the square, and the distance B I = H F will be equal to I G, which being added to I F = B H, will give G F, the altitude.

Also, if the angle be greater than 45 degrees, as in the right hand figure, then, by similar triangles, the part of the side cut off from B C will be to the whole side, A B, as B I to I G. So that if the part cut off from B C be 8 divisions, of which A B is 10, and the distance L F be 36 feet, it will be

As 8 : 10 :: 36 : $\frac{360}{8}$ = 45 feet. To which add, F I for the altitude.

And, if the angle be less than 45 degrees, as in the left hand figure, then the part to be cut off will be on the other decimated side, and the proportion will be,

As the whole side A D,
Is to the part cut off from C D;
So is the distance B I,
To the altitude I G.

Thus, if the part cut off from C D, be 4·5 divisions, and the distance P F, 100 feet, it will be,

As $10 : 4{\cdot}5 :: 100 : \frac{450}{10} = 45$ feet. To which add F I for the altitude.

V. By Means of a Portable Barometer and Thermometer.

Observe the altitude, B, of the mercurial column, in inches, tenths, and hundredths, at the bottom of the hill, or other object, the height of which is required. Observe also, the altitude, *b*, of the mercurial column at the top of the object. Observe the temperatures on Fahrenheit's thermometer at the times of the two barometrical observations, and take the mean between them. Then, $55000 \times \frac{B-b}{B+b}$ = the height of the hill, in feet, for the temperature of 55 degrees on Fahrenheit. Add $\frac{1}{440}$ of this result for every degree which the mean temperature exceeds 55 degrees, and subtract as much for every degree below 55 degrees.

This will be a good approximation when the height

of the hill is below 2000; and it is easily remembered, because 55 degrees, the assumed temperature, agree with 55, the effective figures in the co-efficient, while the effective figures in the denominator of the correcting fraction, are two *fours*.

Distances.

I. By Means of two Pickets.

Take two pickets of unequal lengths, drive the shortest into the ground, say close to the edge of a river; measure some paces back from it, and drive in the other till you find, by looking over the tops of both, that your sight cuts the opposite bank.

Next, pull up the first picket, measure the same distance from the second, in any direction the most horizontal, and drive it as deep in the ground as before.

Then, if you look over them again, and observe where the line of sight falls, you will have the distance required.

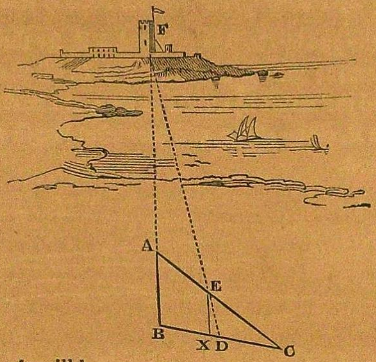
This method is, of course, applicable only to very short distances.

II. By Means of a Triangle.

Suppose F to represent the object, and A F the distance required.

Then, with a measuring tape, lay down any convenient length, A B in the direction A F; also, B C, in any convenient lateral direction, and join A C.

Bisect B C in D, and set up a staff or arrow at E, directly between D and F, upon the line A C, and measure A B, A E, and E C.



Then it will be,

As C E — E A : E A : : A B : A F. The distance required.

Thus, supposing A B to be 60 feet, A E 50 feet, and E C 80 feet, the proportion will be,

As 80—50 : 50 : : 60 : 300 feet.

This problem may be demonstrated as follows :—

By sim. tri. C X : X E : : B C (=2 B D) : B A.

And, X E : D X : : B F : B D.

Or, X E : 2 D X : : B F : 2 B D;

Ex equali, C X : 2 D X : : B F : B A.

By division, C X : B X : : B F : A F.

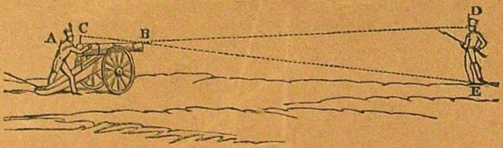
But, C E : A E : : C X : B X.

Therefore, C E : A E : : B F : A F,

And by division, C E—A E : A E : : A B : A F. Q. E. D.

III. By Means of the Tangent Scale of a Gun.

Lay the gun by the line of metal A B, for the top of the object D; then raise the scale A C, till the top of it C, and the notch B, on the muzzle, are in line with the foot E, of the object, and note what length of scale is required.



Then, by similar triangles, it will be,

As A C : A B : : D E : B D. The distance required.

Thus, supposing the height, D E, of the object to be 6 feet, the length of C of the tangent-scale 3 inches; and of the gun 5 feet, 6 inches, the proportion will be,

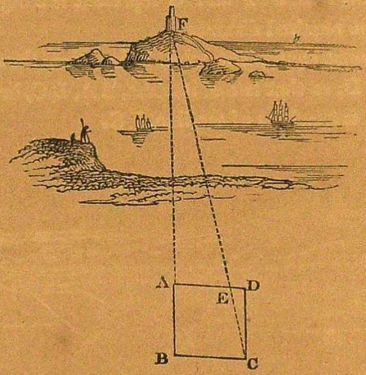
As 3 : 66 : : 72 : 1524 inches, or 132 feet.

It will be perceived that this method supposes the third term of the proportion, D E, to be known.

IV. By Means of a Rhombus.

Suppose F the object, and A F the required distance, as in the second problem.

With a line or measuring tape, of a length equal to the side of the intended rhombus, the longer the better, lay down one side, A B, in the direction, A F, and also with a second tape, B C, another side, in any convenient direction,—for whether B be a right angle or not, is of no consequence; and put up two rods or arrows at A and C.



Then fasten two ends of two such lines at A and C, and extend them until the two other ends just meet at D. Let them lie thus stretched upon the ground, and they will form the other two sides, A D, C D, of the rhombus.

Next, fix a mark or arrow at E, directly between C and F, upon the line A D, and measure A E, and E D, upon the tape.

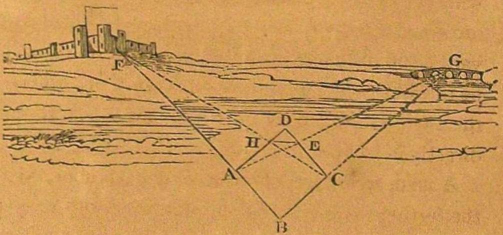
Then, by the property of similar triangles, it will be,

As E D : C D : : A E : A F. The distance required.

Otherwise, when the Distance between two Inaccessible Objects is Required.

In this case, let F and G represent the objects, and F G the required distance.

At some convenient point, B, lay down the rhombus, A B C D, so that two of its sides, B A, B C, be directed to the extremities of the line, F G.



Next mark the intersections, E and H, of A G, C F, with the sides of the rhombus, as in the case above; and the triangle, H D E, will be similar to the triangle G B F, and E H parallel to F G.

Then, by similar triangles, it will be,

As E D : D A : : B A : B G.

And, D H : E H : : B G : F G. The distance required.

V. By Means of a Micrometer attached to a Telescope.

Portable instruments have been invented by Martin, Cavallo, Dolland, Brewster, and others, for the purpose of measuring extremely small angles. In employing them for the determination of distances, all that is necessary in practice is to measure the angle subtended by an object of known dimensions, placed either vertically or horizontally, at the further extremity of the line, the length of which we wish to ascertain.

Thus, if there be a house or other erection built with bricks of the usual size, then four vertical courses are equal to a foot, and four horizontal courses to a yard; and distances measured by means of these will be tolerably accurate, if care be taken, when observing the angle subtended by the horizontal object, to stand directly in front of it.

A man, a carriage wheel, a window, a door, &c. at the further extremity of the distance we wish to ascertain, may serve for an approximation; but in all cases where it is possible, let a foot, a yard, or a six-feet measure, be set up vertically, at one end of the line to be measured, while the observer, with his micrometer, stands at the other.

Then, if h be the height of the object, either

$\frac{1}{2} h \times$ cot. $\frac{1}{2}$ angle subtended, or

$h \times$ cot. angle will give the distance, accord-

ing as the eye of the observer is horizontally opposite to the *middle*, or to *one extremity* of the object.

When a table of natural tangents is not at hand, a *very* near approximation for all angles less than *half a degree*, and a *tolerably* near one up to angles of a *degree*, will be furnished by the following rules :—

1. If the distant object, of which the angle is taken, be 1 foot in length,

Then,

3437·73 ÷ the angle in minutes, } will give the
or 206264 ÷ the angle in seconds } distance in feet.

2. If the distant object be 3, 6, 9, &c. feet in length, multiply the former result by 3, 6, 9, &c. respectively.

By means of the following table, which is calculated for every half minute up to one degree, the results of such angles as fall within those limits may be ascertained by inspection only.

Thus, suppose an extension of one foot is found by the table to subtend an angle of 22 minutes, the distance will be 156 2 feet; and suppose at the distance 171·8 feet an object subtend an angle 20 minutes, its altitude will be one foot.

Again, suppose an object 6 feet high to subtend an angle of 20 minutes, then by the rule, 171·8 × 6 = 1030·8 feet will be the distance.

Table of Angles subtended by a Foot at different Distances.

Angles.		Distances	Angles.		Distances	Angles.		Distances	Angles.		Distances
Min.	Sec.	Feet.	Min.	Sec.	Feet.	Min.	Sec.	Feet.	Min.	Sec.	Feet
0	30	6875·5	15	30	221·8	30	30	112·6	45	30	75·5
1	0	3437·7	16	0	214·8	31	0	110·9	46	0	74·7
1	30	2291·8	16	30	208·3	31	30	109·1	46	30	73·9
2	0	1718·9	17	0	202·2	32	0	107·4	47	0	73·1
2	30	1375·0	17	30	196·4	32	30	105·7	47	30	72·3
3	0	1145·9	18	0	191·0	33	0	104·2	48	0	71·6
3	30	982·2	18	30	185·8	33	30	102·6	48	30	70·8
4	0	859·4	19	0	180·9	34	0	101·1	49	0	70·1
4	30	763·9	19	30	176·1	34	30	99·6	49	30	69·4
5	0	687·5	20	0	171·8	35	0	98·2	50	0	68·7
5	30	625·0	20	30	167·6	35	30	96·8	50	30	68·0
6	0	572·9	21	0	162·7	36	0	95·5	51	0	67·4
6	30	528·9	21	30	159·9	36	30	94·2	51	30	66·7
7	0	491·1	22	0	156·2	37	0	92·9	52	0	66·1
7	30	458·3	22	30	152·8	37	30	91·6	52	30	65·4
8	0	429·7	23	0	149·4	38	0	90·4	53	0	64·8
8	30	404·5	23	30	146·3	38	30	89·3	53	30	64·2
9	0	382·0	24	0	143·2	39	0	88·1	54	0	63·6
9	30	361·9	24	30	140·3	39	30	87·0	54	30	63·1
10	0	343·7	25	0	137·5	40	0	85·9	55	6	62·5
10	30	327·4	25	30	134·8	40	30	84·8	55	30	61·9
11	0	312·5	26	0	132·2	41	0	83·8	56	0	61·4
11	30	298·9	26	30	128·4	41	30	82·4	56	30	60·8
12	0	286·5	27	0	127·3	42	0	81·8	57	0	60·3
12	30	275·0	27	30	125·0	42	30	80·9	57	30	59·8
13	0	264·4	28	0	122·7	43	0	79·9	58	0	59·2
13	30	254·6	28	30	120·6	43	30	79·0	58	30	58·7
14	0	245·5	29	0	118·5	44	0	78·1	59	0	58·2
14	30	237·0	29	30	116·5	44	30	77·2	59	30	57·7
15	0	229·2	30	0	114·6	45	0	76·4	60	0	57·3

See also the words LEVELLING and SOUND.

DRAG-ROPES.

Weight and Dimensions of Drag-Ropes.

		Length.	Weight.
For....	8 men	23 feet 6 inches	1 pair 32 lbs.
	6 men	18 6	ditto 21

EMBARKATION.

In embarking Ordnance Stores, the first thing necessary is to prepare a list of all the articles to be embarked, with the weight and tonnage of each. This list must have a large column for remarks. The tonnage required for bulky articles, will be generally one-third more than their actual weight; but the tonnage of Ordnance, Shot, Shells, &c. will be equal to their weight.

If vessels be paid for according to the tonnage they carry, the masters will, of course, stow away as much as the ships will hold; but, if by the voyage, they will be averse to loading their ships too much; a naval officer should therefore always attend to see that the ships are properly stowed.

Ordnance and Stores may be embarked, either for the purpose of merely transporting them to another situation, or for a military expedition. In the first case, each ship must be stowed with as much as it will carry, and every article that relates to one particular species of service, or ordnance, must be put on board the same ship, that in case one ship be lost the others may remain in themselves complete. This principle

must, of course, likewise be attended to, in an embarkation for an expedition, but a more particular distribution of the stores must take place when on board. With each piece of ordnance must be placed every thing necessary for its service; its side arms, carriage, limber, ammunition waggon, ammunition, &c. so as to be readily come at when required to be disembarked.

If it be an embarkation of ordnance, &c. for a siege, not only every thing necessary for the service of the ordnance should be embarked with them, but also every thing necessary for the construction of the battery on which they are to be mounted. It will be advisable, in this case, to put different natures of ordnance in the same ship, in proportions according to the service required of them. In general, it will be best to put the heavy articles in first, and every thing that is light, easy to be removed, or likely to be first wanted, on the top.

Previously to embarkation, the guns, carriages, waggons, &c. must be dismounted, but first numbered as follows, and the number of each article marked in the list of the column of remarks. Give each piece of ordnance and its carriage the same number: give the ammunition waggons and the other carriages different numbers from the ordnance carriages: then give every limber, whether of ordnance carriage, or ammunition or other waggon, the number of its respective carriage. If for a simple transport, arrange

the small-stores, side-arms, &c. according to their several natures; but if for an expedition, every thing belonging to each particular piece of ordnance must be collected together, and the cases, or chests in which they are put, marked with the number of the piece of ordnance to which they belong, their natures, and description. If there be any doubt of the different parts of the carriages, being made with that uniformity so essentially necessary, every part that is separated must bear the number of its carriage. This precaution, at any rate, may be a good one, if the same vessel contains different natures of ordnance or carriages.

The axle-trees need not be taken off the carriages if the vessel be of sufficient size to admit them when fixed, as they are not easily replaced without workmen, and a tedious operation.

When a carriage is dismounted, all the small articles, such as elevating-screws, linch-pins, drag-washers, cap-squares, &c. must be carefully collected, and secured in a box, marked with the description of stores, and number of the carriage to which they belong.

All carriages or waggons embarked with their axle-trees fixed, must be arranged in the ship, side by side, and alternately front and rear, that their axle-trees may not interfere with each other, and take up too much room.

Every transport, or other vessel, employed in the conveyance of troops or stores for an expedition, should be numbered on the quarters, and on the bows,

with figures as large as two or three feet, and likewise on the sails, that they may be known at a distance. The number of the ship, her name and tonnage, and the master's name, must be entered in the list of stores which she carries.

In disembarking ordnance and stores, they must be landed in order exactly the reverse of that in which they were shipped. The carriages and waggons must be mounted as soon as possible, and each piece of ordnance, with its waggon, &c. must be arranged as far from the shore as possible, to prevent confusion.

If the disembarkation be to take place in the presence of an enemy, the vessels, of course, must be loaded accordingly; and the field ordnance, with their carriages, ammunition, &c. must be so arranged as to be first landed, and with the greatest possible ease. In this case, the intrenching tools must also be kept in the greatest readiness.

ELEVATION.

The elevation of a piece of ordnance is the angle formed by the axis of the bore, and an imaginary line passing through its interior extremity, and parallel to the plane on which it stands. Thus, if a gun be situated on a plane inclined to the horizon at an angle of three degrees, and the angle which the axis of its bore makes with the horizon be four degrees, the elevation of the gun will be only one degree. Hence, in ascending planes, the elevation of the gun is equal to the

difference of the elevations of the plane and gun above the horizon; and, in descending planes, it is equal to the difference of the depressions of the plane and gun below the horizon.—See the word POINT-BLANK.

EXERCISE.

The several exercises are divided into three classes, as follows:—

1. Exercise of Field Artillery.
2. Exercise of Garrison or Siege Artillery.
3. Exercise of the various Machines employed in the Manœuvres of Garrison or Siege Artillery.

I.—EXERCISE OF FIELD ARTILLERY.

The complement of men for the service of each gun or howitzer, is, one non-commissioned officer and eight gunners.

Numbering and Telling off the Detachments.

The different detachments being arranged, right in front, are numbered and told off by their respective non-commissioned officers in the following manner:—

The non-commissioned officer is invariably number 1, and is responsible that the duties of the other numbers of his detachment are properly executed. The right hand man of the rear rank is named number 2,—his front rank man, number 3; the second man from the right of the rear rank, number 4,—and

his front rank man, number 5; and so on in succession, from the right of the rear, to the left of the front rank, till the whole detachment is completed.

Formation in Order of March or for Exercise.

When the detachments are formed in the order of march, or for the purpose of exercise, the even numbers are, almost invariably, on the right or off-side of the gun; and the odd numbers, on the left or near-side.

Positions of the several Numbers in Action.

Number 1, is on the left of the hand-spike; 2, outside the right wheel, in line with the muzzle; 3, outside the left wheel, and also in line with the muzzle; 4, clear of the right wheel, covering number 2, and in line with the breach; 5, clear of the left wheel, covering number 3, and also in line with the breach; 6, five paces in rear of, and covering the left wheel; 7, in rear of the limber; 8, ten yards in rear of the gun, in line with the heads of the leading horses of the limber; and 9 attends the ammunition waggon.

Duties of the several Numbers.

Number 1, points and commands; 2, sponges; 3, loads; 4, serves the vent and primes; 5, fires; 6, serves 3 with ammunition; 7, supplies 6 with ammunition, and, when firing shells, fixes the fuzes; 8, assists 7, and occasionally relieves number 2, or, when

attached to 5½-inch or 24-pounder howitzers, provides 3 with shells; 9, assists in preparing ammunition.

The following Table shews the Distribution of the several Duties with Reduced Numbers:—

Numbers Retained.	Distribution of Duties.								
	1.	2.	3.	4.	5.	6.	7.	8.	9.
1.2.	1.4.5.	2.3.6.							
1.2.3.	1.4.5.	2.	3.6.						
1.2.3.4.	1.	2.	3.6.	4.5.					
1.2.3.4.5.	1.	2.	3.6.	4.	5.				
1.2 3.4.5.6.	1.	2.	3.	4.	5.	6.			
1.2.3.4.5.6.7.	1.	2.	3.	4.	5.	6.	7.		
1.2.3.4.5.6.7.8	1.	2.	3.	4.	5.	6.	7.	8.	

The figures in the horizontal column at the top of the above table refer to the duties, as already explained, for complete detachments; and the figures in the vertical columns specify the additional duties the numbers perform, according to the strength of the detachment. Thus, for example, when the detachment is reduced to four men, 3 and 4 perform the duties of 6 and 5, in addition to their own.

Limbering Up, or Retiring from Action.

This manœuvre may be performed, according to circumstances, to the Front, Rear, Right or Left.

In limbering up to the *Front*, the limber drives up to the *Right* of the gun. Number 2, passes his sponge over the axle-tree to 4, who straps on the sponge-head; 2 and 3, go round to the trail; 4 and 5, man the wheels—assisted by 7 and 8, with heavy guns. The right wheel is run back, the left, forward; and 1 and 6, throw the trail round in the opposite direction to that in which the limber drives up.

The instant the trail is round, number 1 unships his hand-spike, and 5 straps it on; 2, buckles on the rammer-head of his sponge, and the whole fall in close to the wheels. Numbers 6, 4, and 2, on one side; 5, 3, and 1, on the other; 7, attends the limber; and 8, moves up to his place.

On the limber's coming up square to the front, number 1, orders "*Halt Limber Up*:" upon which 4 and 5, man the wheels,—assisted by 7 and 8 with heavy guns;—2, 3, and 6, lift the trail and place it on the pintail; number 1, then puts in the key, and the detachment mount or fall into the order of march.

The duties are precisely the same in limbering up to the Rear, Right, or Left, except that in limbering up to the Right or Left, the trail and limber both go to the Right or Left; and in limbering up to the Rear, the limber drives up rather to the Right of the trail, which is not thrown round, and then reverses to the Left.

Unlimbering, or Coming into Action.

This is precisely the reverse of the preceding manœuvre.

Number 1, unkeys the pintail; 2 and 3, raise up the trail, and when it is clear, 1, gives the word "*Drive On*," upon which the limber goes off to the *Left about*, and the trail is thrown to the *Right-about*; the other numbers assisting, as they arrive, the same as in limbering up; 6, at the trail, with heavy guns, and 4 and 5, at the wheels. As soon as the trail is down, number 5, unbuckles the hand-spike, and 1, ships it; 2, unstraps the rammer-head, and goes to his place; and 4, unstraps the sponge and passes it over to 2.

When the limber is sufficiently to the rear, it reverses to its *left*, and halts ten yards in rear of, and covering, its gun. The ammunition waggon also reverses to its *left*, goes off in front of the limber, reversing again to its *left*, and halts one horse's length in rear of the gun-limber.

Number 1, is responsible for the correct dressing of his gun when it comes into action, and for this purpose, immediately the trail is in its proper direction, he should place himself in line with the axle-tree of the gun upon which the formation is made, and dress his own gun with it. This position will enable him to see, not only that his gun is in its true alignement, but also that it is square to the front.

II.—EXERCISE OF GARRISON, OR SIEGE ARTILLERY.

This second branch of the exercises relates to the manner of working and serving Guns, Howitzers and Carronades, and Mortars on batteries.

GUNS.

Complement of Men for the Service of Garrison Guns.

The complement of men for the service of garrison, or battery guns, is, for the 42 and 32-pounders, one non-commissioned officer and six gunners each; for the 24-pounder, one non-commissioned officer and five gunners; for the 18-pounder, one non-commissioned officer and four gunners; and for the 12 and 9-pounders, one non commissioned officer and three gunners each.

All calculations for the daily service of guns on batteries should be in these proportions, and at three reliefs.

Numbering and Telling off the Detachment.

The detachments for the service of heavy ordnance are told off and numbered in precisely the same manner as for field-guns.

Formation for Exercise.

The same in every respect as for field artillery.

Positions of the Numbers.

Number 1, directly in rear of the gun; 2, on the right of, and in line with, the muzzle; 3, on the left of the muzzle, and also in line with it; 4, on the right of the gun, clear of the truck, and in line with the breech; 5, in the same relative position on the left of

the gun; and the remaining numbers on the right and left of the embrazure, with their backs to the merlons.

The whole of the numbers, when not immediately employed in working the gun should arrange themselves, in order, under cover of the parapet.

Duties of the several Numbers.

Number 1, points, commands, and assists to run the gun up; 2, sponges, runs up, and elevates; 3, loads, runs up, and elevates; 4, serves the vent, primes, runs up, and traverses; 5, fires, runs up, and traverses; 6, serves 3 with ammunition and runs up; 7, assists to run up.

The following Table will show the Distribution of the Duties when the Numbers are Reduced.

Numbers Retained.	Distribution of Duties.					
	1.	2.	3.	4.	5.	6.
1.2.3.	C.V.P.R.F	S.R.E.T	A.L.R.E.T.			
1.2.3.4.	C.V.P.R.	S.R.E.T	L R.E.T.	A.R.F.		
1.2.3.4.5.	C.R.	S.R.E.	L.R.E.	V.P.R.T	A.R.T.F	
1.2.3.4.5.6	C.R.	S.R.E.	L R.E.	V.P.R.T	R.T.F.	A.

References.

C. Points and commands. V. Serves the vent.
S. Sponges. P. Primes.

L. Loads.
F. Fires.
T. Traverses.
R. Runs up.
E. Elevates.
A. Serves ammunition.

HOWITZERS AND CARRONADES.

The complement of men, duties, &c. are precisely the same for howitzers and carronades, as the above for guns.

MORTARS.

Complement of Men for the Service of Mortars.

The established complement of men for the service of mortars on batteries is as follows:—For the 13-inch, one non-commissioned officer and five gunners; for the 10-inch, one non-commissioned officer and four gunners; for the 8-inch, one non-commissioned officer and three gunners; and for the royal and cœhorn mortars, one non-commissioned officer and two gunners each.

Numbering and Telling off the Detachment.

The mode of numbering off the detachments, &c. is precisely the same as the above for guns.

Formation and Positions of the Several Numbers.

The formation, whether for exercise or in the order of march, is precisely the same as for guns.

Number 1, directly in rear of the mortar; 2, on the right of, and in line with, the front of the bed; 3, in the same relative position on the left of the bed; 4, on the right of the mortar, covering 2, and in line with

the vent; 5, in the same relative position as 4, on the left of the mortar; 6, at the magazine.

Duties of the Several Numbers.

Number 1, points, commands, and serves the vent; 2, sponges, runs up, and traverses; 3, loads, runs up, and traverses; 4, runs up, elevates, supplies shells, primes, and traverses; 5, runs up, supplies shells, elevates, traverses and fires; 6, serves ammunition.

The following Table shews the Duties performed by each Man, in Serving and Working Mortars with Reduced Numbers:—

Numbers Retained.	Distribution of Duties.				
	1.	2.	3.	4.	5.
1.2.	C.A.V.B.R.P	S.L.R.E.T.F			
1.2.3.	C.V.P.	S.R.E.T.	A.B.L.R.E.T.F		
1.2.3.4.	C.V.P.	S.R.E.T.	A.L.R.E.T.	B.F.	
1.2.3.4.5	C.V.	S.R.E.T.	A.L.R.E.T.	R.E.P	R.B.F

References.

C. Points and commands.
S. Sponges.
L. Loads.
V. Serves the vent.
P. Primes.
F. Fires.

R. Runs up. A. Serves ammunition.
B. Supplies shells. E. Elevates.
T. Traverses.

Number 2 puts the shells into the 8, $5\frac{1}{2}$, and $4\frac{2}{5}$-inch mortars, and is assisted by number 3, in putting them into the 13 and 10-inch mortars.

III.—EXERCISE OF THE VARIOUS MACHINES EMPLOYED IN THE MANŒUVRES OF HEAVY ARTILLERY.

The method of numbering, telling off, &c. is the same in every respect for this branch of the exercises, as for the two preceding branches; except, that in the exercise of the Devil Carriage, the odd numbers are on the right side, and the even numbers on the left.

Exercise of the Triangle Gyn.

The complement of men for a triangle gyn, is usually one non-commissioned officer and ten gunners. The following are the duties in carrying or working the gyn.

Left Side.

3. Carries at the foot of the left cheek, works the left hand lever, keys and unkeys the left hand cap-square of the gun-carriage, and assists to run the carriage up or back.

Right Side.

2. Carries at the foot of the right cheek, works the right hand lever, keys and unkeys the right hand cap-square of the gun-carriage, and assists to run the carriage up or back.

5. Carries at the top of the left cheek, works the left centre lever, and assists to run the carriage up or back.

4. Carries at the top of the right cheek, works the right centre lever, and assists to run the carriage up or back.

7. Carries the levers and hand-spikes, assists number 6 in passing the fall round the windlass, and holds on next to him.

6. Carries the windlass, passes the fall round it, holds on, makes it fast, and eases off and lowers the gun.

9. Carries at the top of the pry-pole, with the slings, fid, trucks, &c., holds on the fall behind number 8, and coils it up as it comes off.

8. Carries at the foot of the pry-pole, with the slings, fids, trucks, &c. and holds on next to number 7.

11. Assists in carrying the blocks and fall, reeves and unreeves the triple-block, assists in slinging the gun, and steadies it at the muzzle.

10. Assists in carrying the blocks and fall, reeves and unreeves the double block, assists in slinging the gun, and steadies it at the cascable.

When plenty of men are at hand, a battering gun may be mounted by laying it upon its bed and quoin, with the vent downwards, and then placing the

carriage on the top of it, so that the trunnions fit into the trunnion boxes. The gun and carriage are then woulded together close to the trunnions, and the drag-ropes are made fast round the gun to the carriage.

In this state the men must be equally divided upon these ropes, and upon four hand-spikes having a purchase under the gun; the word is then given to pull—the men do so steadily—the hand-spike men heaving at the same time, till the gun and carriage are brought over.

In this manœuvre, great care must be taken not to pull too much when the gun is upon the balance.

Exercise of Bell's Gyn.

The complement of men for working this gyn is, one non-commissioned officer and six gunners.

Left Side.

3. Runs the carriage up or back, assists number 6 in slinging the gun, turns the winch, assisted by number 5, opposite to him, or makes fast and hauls upon the rope, which is passed round the handles of the winch.

Right Side.

2. Runs the carriage up or back, assists number 7 in slinging the gun, turns the winch, assisted by number 4, or holds on upon the rope, and makes it fast, the same as number 3.

5. If necessary, runs the carriage up or back, and assists number 3, at the winch.

4. Performs similar duties to number 5, on his own side.

7. Assisted by number 2, slings and unslings the gun at the chace, and steadies it at the muzzle.

6 Assisted by number 3, slings and unslings the gun near the first reinforce-ring, places the bed and quoin, and steadies the gun at the cascable.

Exercise of the Gibraltar Gyn.

The complement of men required to work this gyn, is one non-commissioned officer and six gunners.

Left Side.

3. Runs the carriage up and back, assists number 2, in heaving the windlass round, standing outside the gyn and fronting him, and assists number 6 in slinging the gun.

5. If necessary, runs the carriage up or back, assists in holding on the

Right Side.

2. Runs the carriage up and back, heaves the windlass round, standing inside the gyn and fronting number 3, and assists number 7 in slinging the gun.

4. Runs the carriage up or back, holds on the fall when the gun is being

fall, and stoppers and unstoppers it when it requires shifting.

7. Assisted by number 2, slings and unslings the gun at the chace, and steadies it at the muzzle.

raised, makes the fall fast, and lowers the gun.

6. Assisted by number 3, slings and unslings the gun near the first reinforce-ring, places the bed and quoin, steadies the gun at the cascable, and, when ordered, overhauls the tackle.

The front of the Gibraltar Gyn is the part next the moveable axle-tree; the rear, where the windlass is fixed.

Exercise of the Sling Cart.

The complement of men is one non-commissioned officer and six gunners.

Left Side.

3. Has charge of the left lever, and, when necessary, assists to skid the gun.

5. Assists number 2 at the lever and skidding, and, when the gun is to be lashed, assists in raising the breech.

Right Side.

2. Has charge of the right lever, and, when necessary, assists to skid the gun.

4. In like manner assists number 2, and, when the gun is to be lashed, assists in raising the breech.

7. Assists number 3 at the lever, slings and unslings the gun, and lashes it to the pry-pole.

6. Assists number 2 at the lever, assists in slinging and unslinging the gun, and lashing it to the pry-pole.

The non-commissioned officer puts in and takes out the pauls, and commands.

Exercise of the Devil Carriage.

The complement of men for working this carriage is one non-commissioned officer and ten gunners.

Right Side.

3. Has charge of a drag-rope, assists in hauling the perch up and down, bears the muzzle of the gun down, and, when the breech is raised, puts the lever into the muzzle, it being carried there when the gun is slung.

5. Steadies the gun-carriage when raised on its breast transom, and, with the long guy-rope, lashes its front axle-tree to the devil-carriage.

Left Side.

2. Has charge of a drag-rope, assists in hauling the perch up and down, assists number 3 in bearing the muzzle down, and, when the gun and carriage are lashed on, puts up the skid.

4. On his side, performs similar duties to those of number 5.

7. Slings the gun, lashes the breech to the perch, assists in limbering up and unlimbering, and slings the gun-carriage.

6. Performs similar duties to number 7.

9. Has charge of one of the short guys, assists in unlimbering and limbering up, and in hauling the breech of the gun up to the perch, lashes the hind axle-tree of the gun-carriage to the devil-carriage, and fixes the long guy-rope to the iron eyes at the end of the perch.

8. Performs similar duties to number 9.

11. Assists in unlimbering and limbering up, and in hauling the breech of the gun up to the perch, lashes, with the short guy-ropes, the rear axle-tree of the gun-carriage to the devil-carriage, and fixes the short guy-ropes to the ring under the perch.

10. Performs similar duties to number 11.

FASCINES

Are a species of long cylindrical faggots, and have different names, according to their sizes and use.

1. *Saucissons* are usually made from 18 to 20 feet long, and from 10 to 12 inches thick. They are used for the revêtement of the cheeks of the embrasures of a battery, or for retaining the earth of extensive epaulements.

2. *Battery Fascines* are from 8 to 10 feet long, and from 10 to 12 inches thick. They are employed in the revêtement of the parapets, and general construction of batteries, &c.

3. *Trench Fascines* are from 4 to 6 feet long, and from 6 to 9 inches thick. They are used at sieges in carrying on the approaches.

4. *Water Fascines* 6 feet long, and from 1 to 2 feet thick, are intended to cover a wet or marshy situation, as also to form the passage of a wet ditch. They should consequently be loaded with stones to make them sink.

5. *Covering Fascines* are used in roofing magazines, saps, &c. They ought, therefore, to be composed of the strongest branches, with the addition of a few poles, that they may bear a considerable weight.

6. *Sap Faggots* are usually about 3 feet long, and 9 inches thick. They are used in the sap to strengthen the parapet by filling up the vacant spaces between

the gabions. There is generally a sharp pointed stake in the centre of each faggot, which, when they are placed, being driven into the ground, secures them in their situations.

PROCESS OF MAKING FASCINES.

A number of small trestles are first to be formed, by driving stakes crossways into the earth, and binding them together in the centre, about 2 feet from the ground, with cords. The number of these crosses or trestles, constituting what is called the *fascine bench*, must of course depend upon the intended length of the fascines. They are usually placed about 3 feet apart, and form so many forks, in which the brush-wood is laid.

Three men are generally employed in preparing each fascine:—two to place the branches on the bench, and choke the fascine, which they do by passing a rope with a loop at each end, round it; through these loops they each put a stake or hand-spike, and bearing down on them, in opposite directions, draw the branches together. The third man prepares the bands of birch, hazel, or other pliant wood, well twisted, which are placed about two feet apart, and, when the fascine is choked, binds it fast.

In laying the branches in the trestles, care must be taken to place the shortest inside.

Birch and hazel are the best woods for this work.

Tools and Workmen required for each Bench.

To every bench, from 4 to 6, and, when preparing very large fascines, from 8 to 10 workmen are allowed, three of whom are employed as above explained, and the others in cutting the brushwood. The tools are a hatchet, a fascine knife, a choke, a gauge, and a measuring rod, in the first instance; but in the second, two additional hatchets must be added; and in the third, from four to six hatchets, besides those above-mentioned.

To estimate the Number of Fascines required to revête any Work.

Divide the length of the work by the length, and the height by the thickness, of a fascine. Then the product of the two quotients thus obtained, will be the number required.

Example. How many fascines, each 10 feet long and 9 inches thick, are required to revête an epaulement 100 feet in length and 6 feet high?

Here $100 \div 10 = 10$. The number of fascines in each course.

Again $\frac{6 \times 12}{9} = \frac{72}{9} = 8$. The number of courses.

Therefore, $10 \times 8 = 80$, the number of fascines required.

For every four feet of fascine there must be allowed

a picket an inch and half thick. These pickets are driven through the fascines when they are used for the revêtement of slopes One half of these pickets should be 6 feet, and the other half from 2 to 4 feet in length; in addition to this, an understake, 6 feet long, will be required for every 6 or 10 feet of fascine.

FLINTS

Were formerly packed in half barrels, in the following quantities.

Nature of Arm.	Flints in each Half-Barrel.	Weight. qrs.	lbs.
Musquet	2,000	2	14
Carbine	3,000	2	10
Pistol	4,000	2	15

The present mode of package is in strong canvas bags, each containing, of—

Musquet	English	200	Flints.
	French	500	
Carbine	English	400	
Pistol		750	

They are thus packed for the convenience of mule transport, when the exigency of the service requires the division of the ammunition into small parts; so that every mule, loaded with a given number of ball cartridges, may, at the same time, carry the allotted proportion of flints:—viz. 1 to every 10 rounds.

For carriage transport, they are packed in boxes, in the proportion of 5 bags to each. A box will therefore contain the following quantities of each nature.

Nature of Arm.		Flints in each Box.	Weight. lbs.	ozs.
Musquet....	English....	1,000	48	$6\frac{1}{2}$
	French	2,500	50	$9\frac{1}{4}$
Carbine	English ..	2,000	48	$14\frac{1}{2}$
Pistol		3,750	53	3

The most transparent and free from veins are esteemed the best flints.

Dimensions of the Flint Box.

	Exterior. ft.	in.	Interior. ft.	in.
Length	1	7·75	1	6·0
Breadth	0	8·5	0	6·75
Depth	0	10·0	0	9·5

FLUIDS (Resistances of).

When bodies move through any fluid with unequal velocities, the number of particles they displace will be proportional to the velocities with which they move; and the force with which each particle of the fluid reacts against the body will also be proportional to the velocity of the body. Consequently, the resistances which the bodies experience in moving through the fluid, will be proportional to the squares of the velocities.

When a body moves through a homogeneous fluid at rest, the resistance it experiences will evidently be the same as that which it would experience if the body were at rest, and the fluid moved against it with a velocity equal to that of the body in the former case. And since the pressure, in every direction, at the base of a vertical filament of fluid, is equal to the weight of that filament, and the velocity with which the particles of the fluid would move off laterally, is produced by that pressure, and, by the laws of hydro-dynamics, is equal to the velocity acquired by a particle falling through the height of the filament; it follows that any surface opposed to this lateral motion would sustain a pressure equal to the weight of a filament of the same height as that which is due to the velocity of the particle. Therefore, the absolute pressure experienced by a plane surface, moving parallel to itself through a fluid at rest, is equal to the weight of a column of the fluid of which the base is equal to the surface opposed, and height equal to the space through which a body must fall vertically, to acquire a velocity equal to that with which the body moves.

This pressure would be experienced by a prism or cylinder, moving through a fluid, in the direction of its axis, or when its extremity is perpendicular to the line of motion. And, by the theory of forces, it will be found, that if the plane surface, or extremity of the body, be inclined to the line of motion, the pressure of the fluid against it, is to the pressure against an

equal surface, perpendicular to the line of motion, as the cube of the sine of inclination is, to the cube of radius.

If a pyramid or cone, or a prism or cylinder, terminating in a pyramidal or conical surface, move through a fluid in a direction parallel to its axis, with its vertex in front, the pressure which the body would experience, is to the pressure on a plate of an area equal to that of the base of the pyramid or cone, as the square of the sine of the inclination of the slant side to the line of motion, is to the square of radius. Therefore, if a cylinder, terminating in a cone, of which a section, made by a plane passing through the axis, is an equilateral triangle, be made to move through a fluid, the resistance it would experience is one-fourth of that which would be experienced by the plane extremity of the same cylinder.

When a cylinder, terminated by a hemisphere, moves in the same manner through a fluid, the resistance on the spherical surface would be equal to half of that which would be experienced on a circular plate, equal to the base of the hemisphere.

By these principles, the amount of the resistance experienced by a cannon shot in moving through the atmosphere, with any given velocity, may be theoretically determined. But the inertia of the shot, in motion, being a force which opposes the pressure of the air upon it, and this inertia being proportional to the mass or weight of the shot, it follows that the

retardation experienced by the shot in moving through the air, is directly proportional to the resistance, and inversely proportional to the weight of the shot.

These circumstances are independent of the pressure arising from the condensation of the air in front, and that arising from the vacuum in rear of the shot, when moving with great velocity; on which accounts, and probably for many other reasons, the results of experiment are very different from those of theory.

From the experiments made by Dr. Hutton, on the resistance experienced by different bodies passing through the air, with velocities of from 3 feet to 20 feet per second, the following results have been obtained.

Two hemispheres, the diameters of which were 4·75 and 6·625 inches respectively, moving with their flat surfaces forward, experienced resistances which were nearly proportional to those surfaces, while the velocity was less than 12 feet per second; but the resistances were in rather a higher ratio when the velocity was greater.

The resistances experienced by the same surfaces, were nearly proportional to the 2·1 power of the velocity.

When the three following bodies were employed: viz., a cylinder, the length and diameter of which were each equal to 6·625 inches; a hemisphere, the diameter of which was 6·625 inches; and a cone, having an

altitude and diameter of base, each equal to 6·625 inches, it was found,

1. That the resistance experienced by the flat ends of the cylinder, hemisphere, and cone, were to each other as the numbers 1, 1·0105, 1·021 respectively.

2. That the resistance experienced by the flat surface of the hemisphere, was to that experienced by the convex surface, as 1 to ·413.

3. That the resistance experienced by the base of the cone, was to that experienced by the vertex, as 1 to ·433.

So that a cone, a section of which, through the vertex, forms a right angled isosceles triangle, experiences greater resistance than a hemisphere, the diameter of which is equal to that of the base of the cone. By theory it should experience less resistance. And the resistance on the base of such a cone, is to that on the vertex, as radius is to the sine of the angle of inclination of the side to the axis. By theory, as above, it should be as the square of radius, to the square of the sine of the inclination.

The resistance on the flat surface of a hemisphere, is to that on the surface of a whole sphere, of equal diameter, as 1 to ·4305. By theory it should be as 1 to ·5.

The resistance on the convex surface of a hemisphere, is to that on the surface of a whole sphere, of equal diameter, as 1 to 1·042.

The resistances experienced by bodies are different, when their fronts are equal and similar, but the opposite parts are of different forms.

Lastly. The resistances experienced by plane surfaces, are greater than the weight of a column of air of a base equal to the area of the surface, and height equal to that which a body must fall through to produce a velocity equal to that of the body in motion. The resistance experienced by the flat surface of the cylinder above-mentioned, moving with a velocity of 20 feet per second, was, by experiment, found equal to 2·528 oz. By theory it should be 1·7904 oz; so that the resistance is really equal to the weight of a column of air of the same base, and a height equal to 1·41 times that required by theory. With a velocity of 10 feet per second, the resistance, by experiment, is ·565 oz.; by theory it is ·448 oz.; so that the actual height of the column is 1·26 times the height required by theory. The proportion is nearly the same, when the velocity is any thing less than 10 feet.

According to the experiments of Borda, the impulse of wind against a plane surface equal to one square foot, when moving with a velocity of one foot per second, is equal to $\frac{1}{500}$ of a pound avoirdupois.

By other experiments, it has been found, that when a flat plate moves through water, with a velocity of one foot per second, the resistance is equal to 1·75 pounds avoirdupois on each square foot of surface.

When the body is of a cubical form, the resistance

against the surface in front, when the velocity is one foot per second, is equal to 1·5 lbs. avoirdupois on each square foot of that surface; and when the length of the vessel is three or four times its breadth, the resistance on each square foot is about 1·33 lbs.

Then, supposing the resistances to be proportional to the squares of the velocities of the body, or of the fluid, the resistance due to any other velocity may be found.

PRESSURE OF FLUIDS AGAINST WALLS.

Since the pressure on any horizontal section of a vessel containing a fluid is equal to the weight of the column of fluid above the section, and that the lateral pressure of a filament of fluid is equal to its vertical pressure; the pressure at any point on the vertical side of the vessel is proportional to the depth of that point below the upper surface of the fluid.

Therefore, if a vertical section of a vessel be taken, the whole pressure against the side of the section may be represented by the area of a right-angled triangle, of which the altitude is equal to the height of the fluid above the bottom, and the base equal to a line expressing the pressure on any point of the bottom; this is equal to half the parallelogram representing the vertical pressure of a lamina of fluid of equal base and altitude. Consequently, if the vessel be rectangular, and the area of the vertical side equal to the area of the bottom, the pressure against that side will be equal

to half the pressure on the bottom; and it follows, that the pressure of a fluid against any upright surface is equal to half the weight of a column of the fluid, the base of which is equal to the surface pressed, and the altitude, to the depth of the fluid.

When any surface, turning on a horizontal joint, coinciding with its upper edge, is pressed by a fluid, moving against it horizontally, the action of the fluid, in turning the plane, is analogous to the action of gravity in making it vibrate upon the same joint. Therefore, the pressure of the fluid on the whole surface is the same as the action of an equal force applied, horizontally, at the centre of oscillation of the plane; that is, if the plane be rectangular, at a point which is below the joint as much as two thirds of the vertical height of the plane.

FORTIFICATION

Is the art of constructing and disposing such works of defence as shall enable a body of men, placed within them, to resist the assaults of larger numbers from without. It is divided into two parts, which are called *Permanent* or *Field Fortification*, according as the works are of a durable or temporary description.

In permanent fortification, the method of construction, which unites, in the greatest degree, simplicity with strength, is that generally known as "*The first System of Vauban, with certain improvements by Cormontaingne,*" and to the development of this com-

bination of principles, therefore, we chiefly confine ourselves.

I.—PERMANENT FORTIFICATION.

The ground to be fortified is supposed to be embraced in a polygon, within which the ENCEINTE or chain of main works is to be contained. The enceinte consists of as many bastions, connected by curtains, as there are sides to the figure, the saliant angles of the bastions corresponding with those of the polygon. The length of each side of the polygon is made as nearly as possible equal to 360 yards, that every part of the enceinte may be within the range of such arms as are employed in the defence. Each side is bisected by a perpendicular, through the interior extremity of which, and from the angles of the polygon, the lines of defence are drawn. The length of the perpendicular, from the point of bisection to the crossing of the lines of defence, is made to bear a proportion of $\frac{1}{8}$, $\frac{1}{7}$, or $\frac{1}{6}$ to the length of the side, according as the figure may be respectively a square, a pentagon, or any superior polygon. As the faces of the bastions are traced on these lines of defence, the above rule for the perpendicular permits the flank to be of an adequate length, without rendering the saliants—or flanked angles, as they are called—of the bastions too acute.

In all polygons of more than six sides, the length of the perpendicular remains unaltered, in order to allow

the flanked angles of the bastions to be as obtuse as possible;—a principle of construction by which the faces of those works are least liable to be enfiladed.

The faces of the bastions are made from 100 to 120 yards long, to afford sufficient capacity to the interior of the bastion; and the flanks are drawn from the extremities of each face perpendicularly, or nearly so, to the opposite lines of defence. The length of the flanks is, by this construction, rendered rather greater than the breadth of the main ditch and terre-plein of the covered-way, in order that its fire may have some superiority over that of the besieger's counter-battery, the length of which is limited by the extent of that space. The length to which the lines of defence are restricted, is such as to permit a fire of small-arms, from each flank, to oppose the construction of that counter-battery; and the angle of defence being a right angle, permits that fire to graze the faces of the collateral bastions. This disposition of the parts of the enceinte enables them to afford each other a reciprocal defence.

The general dimensions of any DITCH should be such, that its excavation shall produce sufficient earth for the formation of the works. The breadth of the main ditch is from 30 to 36 yards, in order that, in passing across it at the time of the assault, the enemy may be for a considerable time exposed to the fire from the works; and its depth should be sufficient to render it difficult to escalade the parapet, as well as

to prevent the besieger, at the crest of the glacis, from being able to see and to breach the foot of the revêtement of the escarpe. The line of the counterscarpe should be drawn from its rounding at the saliants to the interior angles of the shoulders of the collateral bastions, in order that the whole of the ditch may be defended by the fire of the flanks, even to the grazing of the counterscarpe itself, by the musquetry of the file of men who are placed behind the parapet nearest to the shoulder of the bastion.

The Ravelins are intended to cover the curtains and shoulders of the bastions, and to defend the ground in front of their saliants. For these purposes their faces are made about equal in length to those of the bastions, and are directed to points taken on the latter at about 20 or 30 yards from the angles of the shoulder;—a rule of construction by which both a sufficient saliancy is gained for them to oblige the enemy to take two ravelins, in order to avoid their reverse fire, before he can attack the intermediate bastion, and the shoulders of the bastions are also covered from the fire of the counter-batteries, constructed by the besiegers at the saliants of those ravelins.

The ravelin should not be more than 18 yards broad from the magistral line of the face to that of the counterscarpe of the *réduit* within it, that the enemy may not find room on its terre-plein to erect batteries against the réduit.

The faces of the REDUIT in the ravelin should be parallel to those of the ravelin, and the distance between the magistral lines of their escarpes may be about 30 yards, which, leaving about 12 yards for the breadth of the ditch of the réduit, also permits it to be defended by the fire from the faces of the bastions, near the shoulders. The flanks of the réduit should be about parallel to the capital of that work, and long enough to contain, each, three guns, besides such as may be placed in casemates under their parapets. The demi-gorges of the ravelin and réduit, should, if produced, pass through the flanked angles of the collateral bastions, in order to permit the guns, thus casemated, to defend the breach in those angles, and to allow the passages from the *caponnière*, into the main ditch, to be concealed from the view of the enemy at the saliants of the bastions.

The COVERED-WAY is intended to form a communication round the place, and to prevent the enemy from approaching the counterscarpe of the ditch. The covered way should be 10 yards broad, that there may be room to manœuvre in it. The demi-gorges of the re-entering places of arms should be from 40 to 56 yards long, to render those works sufficiently capacious; and the faces should form angles of about 100 degrees with the branches of the covered-way, in order to permit a fire of musquetry to defend the approaches to the saliants of the bastions and ravelins. The re-entering places of arms

should be retrenched by *réduits*, the faces of which must be directed to the re-entering angles of the glacis, in order to prevent them from being enfiladed.

The TRAVERSES in the covered-way are intended to prolong the defence of that work, and to diminish the effect of the enemy's ricochet. The passages between them and the glacis should be formed *en crémaillère*, to prevent the enemy from finding shelter in the crotchets against the fire of the enceinte.

The command of the glacis should be 8 feet, in order to protect the troops in the covered-way, and give their fire a superiority over that of the enemy. Its exterior slope should be very gentle, that the approaches of the besiegers upon it may be exposed to the fire of the interior works.

The relief of the parapet of the ravelin is determined by imagining the height of the gun on the rampart above the ground to be such, that a line of fire from it to the supposed place of the enemy's third parallel, near the foot of the glacis, may pass 3 feet above the heads of the men on the banquette of the opposite covered-way, in order that a fire of musquetry from the latter, and of artillery from the former, may be made at the same time. In like manner, the relief of the parapet of the enceinte may be regulated; but it should have a command of 3 feet over that of the ravelin, or of its réduit, if there be one; and this rule is general for the command of all works over those on their exterior, except the glacis:—the intention

being, that the fire of the interior work may have some superiority over that of the enemy's lodgment in the exterior work when the latter is in his possession.

The faces of the TENAILLE are made to coincide with a vertical plane passing through the lines of defence The use of this work is to cover the postern of the curtain, and to defend the main ditch, and sometimes the interior of the ravelin, by a grazing fire of musquetry. Its relief should be just sufficient to permit, without injury to the defenders on its banquette, a fire of musquetry to be made from the flank of one bastion to the probable place of a breach in the face of the next.

The CAPONNIERE placed in the main ditch covers, in some cases, the communication between the enceinte and the ravelin, but it is exposed to a plunging fire from the crest of the covered-way in front of the saliants of the bastions. To remedy this evil, it should be built of masonry, and covered by a bomb-proof vault, and should have loop-holes in each side for the purpose of sweeping the ditch with musquetry.

The height of the REVETEMENT of the escarpe of any work above the bottom of the ditch should be sufficient to render an escalade impossible; and this object is supposed to be attained when that height is about 30 feet. Yet the cordon or top of the escarpe should be kept about one foot lower than the crest of the glacis, that the enemy may not be able to see

any part of the wall from a distance, and thus to breach it without the necessity of advancing for this purpose to the counterscarpe.

The thickness of the PARAPET near its upper extremity should be about 18 feet, that the shot of a 24 pounder fired from the crest of the opposite glacis may not perforate it. The superior slope of the parapet should be directed in a line to the top of the counterscarpe of the ditch, in order that the covered-way may be defended by a fire of musquetry from the ramparts. The exterior slope of the parapet should form an angle of 45 degrees with the horizon, that the earth may not be subject to crumble down from the action of the weather; and the base of the interior slope of the parapet should be equal to about one-third of the height, that it may be able at once to stand without a revêtement, and to permit the men to fire over the parapet without much constraint. The height of the crest of the parapet should be 7½ feet above the terre-plein of the rampart, that the defenders of the works may be covered; and the banquette should be three feet high, to enable an ordinary sized man to lay his musquet on the parapet in the act of firing. The terre-plein of the rampart should be broad enough not only to afford room for the guns in battery, but for the passage behind them of the carts or men conveying ammunition.

When an ADVANCED DITCH is formed, its bottom should be in the produced plane of the surface of the

interior glacis, in order that it may be defended by the fire of the interior covered-way.

If LUNETTES are constructed beyond the saliants of the bastions and ravelins, those on the latter should be carried as far into the country as possible, provided their saliant-angles are not made less than 60 degrees, and that their faces, if produced to the rear, fall on those of the bastions at 20 or 30 yards from the flanked angles, in order that the ditch of the lunettes may be defended by the artillery on those faces.

By making these works as saliant as possible, the enemy is obliged to begin his operations at the greatest distance from the enceinte:—a necessity which, of course, proportionally retards his subsequent approaches towards the place. The lunettes before the bastions should, on the contrary, be as little advanced as possible, both that they may defend the lunettes on the ravelins, and be themselves subject to a reverse fire from the flanks of those works, if attacked by the enemy before he has got possession of them.

The BASTIONS are frequently retrenched, by a parapet, formed en tenaille, which joins the faces of the bastions within about 20 yards of the shoulders, in order to permit the ditch of the réduit to be defended from the rear of the retrenchment. Sometimes a small front of fortification has been constructed in rear of the gorge of the bastion, to prolong the defence of the place.

When the RAVELIN has no réduit, it may be

retrenched by a parapet en tenaille; but the narrow ravelins of Cormontaingne can only be retrenched by coupures, across their faces; if such be constructed, they should be kept as near the interior extremity of the face as possible, that they may not be turned from the enemy's lodgment at the saliant angle of the ravelin, and their ditch should be cut quite through the parapet of the work.

Narrow COUNTER-GUARDS have occasionally been constructed before the ravelins and bastions, to increase the defence, or to cover a defective revêtement. Those on the ravelins should be more saliant than the others, for the same reason that the ravelins themselves are made more saliant than the bastions.

HORN-WORKS, and CROWN-WORKS, have been frequently constructed to strengthen a weak front, or to occupy a piece of ground which might be of advantage to the enemy. They are, however, easily taken, and produce the inconvenience of permitting the faces of the bastions or ravelins to be breached through the ditch from their saliants. To remedy this defect, it has been recommended to form them beyond the glacis; and to prevent them from being taken by the gorge, their covered-way should be made to join that of the enceinte, or of the ravelin.

See the word REVETEMENT.

II.—FIELD FORTIFICATION.

The works constructed for the temporary mainte-

nance of ground and defence of troops, are Redoubts, Redans, Star and Bastioned Forts, Têtes-de-Pont, and Lines composed of all these works, except the last.

Redans are sometimes employed for the protection of an advanced guard. They consist of two faces forming a saliant angle, which may be defended by works in their rear. The only precaution to be taken in constructing them is, that their saliant angles be not less than 60 degrees.

A Redoubt is either square, polygonal, or circular, and is employed where the detachment may be left for a short time to defend itself. The saliant angles should be directed towards some natural or artificial obstacles, in order to prevent an enemy from marching on the capitals of the work, where the defence is imperfect; and the interior of the parapet, at the angle, may be formed en crémaillère to procure a defence in the direction of the capital, when required. The faces of the crémaillères should be each three feet long, and alternately parallel and perpendicular to the capital.

The capacity of the work should be sufficient to contain the detachment, allowing about 10 square feet for each man; and the periphery of the parapet should be just sufficient to permit the detachment to line it, allowing three feet for each file of men. The ditches of these works may be defended by tambours at the angles, or by covered caponnières across the middle of the ditch, with loop-holes in their sides.

A Star-fort consists of a succession of saliant and re-entering angles, formed on the sides of a polygon, and is employed to secure a post of importance. Its saliant angles should not be less than 60, nor its re-entering angles than 90 degrees; neither should they much exceed those numbers. The faces should not be less in length than 42 feet, that the men behind the parapet of each may be able to see the bottom of the ditch of the collateral face; and the magnitude of the whole work should not be more than sufficient to contain a detachment that may line its parapet, with a reserve, if necessary. A Star-fort, formed by describing equilateral triangles on the sides of a regular octagon, is that which is most conveniently constructed on the ground; and it affords a defence sufficiently good:—but one formed in a similar way on a dodecagon is the most perfect, because its re-entering angles are exactly right ones.

A Bastioned-fort is constructed according to the principles of *permanent fortification*; but the lines of defence are regulated by the range of common musquets, so that the whole length of each front should not exceed 160 yards. The counterscarpe of the ditch is made parallel to the faces, flanks, and curtains of the work; and to permit the fire of the flanks to defend the ditches of the faces of the collateral bastions, the extremities of those ditches are sloped away, in inclined planes, towards the flanks which are to defend them.

Tetes de-Pont consist of redans, or portions of star or bastioned-forts, supported upon the banks of a river, to protect the passage across it. They should be situated in a concave bend of the river, in order that the flanks of the work may conceal the bridge from the view of the enemy, and that those flanks may be defended, if necessary, from the opposite shore.

Of the Lines formed for the intrenchment of armies, those composed of a succession of redans, joined by straight curtains, are best adapted to a level country, because the curtains are not liable to be enfiladed. The distances of the redans from each other should not exceed 120 yards, in order that the fire from the faces of one redan may defend the saliants of the next. Such lines are subject to this disadvantage—that the ditch of the curtain is without defence; and if, to remedy this evil, the curtains be broken, so as to form a saliant angle, the new faces become subject to be enfiladed, unless their prolongations are made to fall within the collateral redans.

Lines formed en crémaillère, are subject to be enfiladed in every part, unless the prolongations of the faces fall on inaccessible points; but they may be employed in situations elevated above the general level of the ground, in front, or along the banks of rivers. The defence of such lines may be increased by forming bastions, or queues-d'hironde, at intervals, along them,

within the reciprocal range of artillery, that, by the fire of this arm, the approach of the enemy may be impeded.

Lines of bastions afford a powerful defence:—their construction is conformable to the rules of Permanent Fortification; but the distance of the bastions from each other should not exceed 160 yards, unless the line is protected by advanced works like lunettes; in which case that distance may be extended to 200 or 240 yards. When such lunettes are employed, they should be placed in front of the curtain, but within the range of musquet shot from the faces of the bastions which are to defend them; and their faces should be directed to the shoulders of the bastions. The curtain between the bastions may be broken, so as to form a re-entering angle in the centre; from which the gorges of the lunettes may be defended.

Broken lines consist of redans, or redoubts, placed at certain distances from each other, in one or two lines; those in the second line being opposite the intervals of those in the first. The works in each line present a saliant angle towards the country, in order that the fire from their faces may defend the ground in front of the intervals, and the faces of the works in the rear line should be perpendicular to those of the front line, in order that their fire may flank them. Broken lines are generally considered preferable to continuous lines, because they permit greater freedom

of sortie; and for a small army they are convenient, as there are fewer points to be manned. But when a retrenched camp is to be formed under the walls of a fortified place, the works may be continuous, because their extent may then be regulated by the number of troops which is disposable to man every part of them. To prevent the enemy from forcing a broken line, the intervals may be occupied by abattis, or other obstacles.

METHOD OF TRACING AND CONSTRUCTING FIELD-WORKS.

In constructing a work, a picket is planted at any point, taken at pleasure, or regulated by the nature of the ground, to represent a saliant-angle of the work; the other saliant points are then determined by placing pickets in such situations that the lines proposed to join them, may be of the required lengths, and that they form with each other angles equal to those between the corresponding faces of the work on the directing plan. This course of pickets represents the magistral line of the work, and then other pickets may, in like manner, be used to trace lines parallel to the first, marking out the horizontal breadths of the several slopes of the parapet, banquette, and ditch. The earth obtained from the ditch forms the remblai, or elevation; it is rammed together and strengthened by fascines, or branches of trees, intermixed with the earth as the work proceeds. The height and slopes

to be given to the several parts of the parapet are indicated by staves placed at the angular points, having the given elevations marked upon them, and the points thus specified are joined by cords or laths.

The height of a simple parapet, above the ground, should be seven feet and a-half, in order to protect the defenders, when the work is not commanded by an eminence. But, should this be the case, the relief of the work must be regulated by the height of the exterior ground.

The thickness of the parapet may be from three to nine feet, according as it may be liable to an attack of musquetry or artillery. The superior slope should be directed to the top of the counterscarpe of the ditch; or, if this cannot be done without weakening the crest too much, a reverse glacis must be raised on the counterscarpe as high as the line of fire, or within three feet of it, that an enemy may not be covered from the fire of the work. For the same reason, the superior slope of the glacis should coincide with the line of fire from the parapet. But to prevent the enemy, at the time of an assault, from plunging his fire into the work, by standing on the glacis, the crest of the latter must in all cases be kept as much as 5 or 6 feet below that of the parapet.

The ditch should not be less than 10 feet broad, that the enemy may not find means to pass it by a moveable bridge, or by laying beams across it; and its depth should be sufficient to afford the earth necessary

to form the parapet. The sides may be sloped so that the horizontal breadth of the escarpe and counter-scarpe, may be one-half, or one-third, of the depth of the ditch, according to the tenacity of the soil; but the exterior slope of the parapet should form an angle of 45 degrees with the horizon, to prevent the newly raised earth from falling down.

A berm 2 or 3 feet broad, is usually left at the foot of the exterior slope of the parapet, in order that the mass of the parapet, being at a distance from the escarpe of the ditch, may not press with such force as to cause the earth to give way.

The exterior of the parapet is generally revêted with fascines, or sods, the latter being placed with their grassy surfaces downwards, in planes perpendicular to the slopes of the parapet. Care must also be taken that the joinings of every two fascines or sods in each horizontal course, may fall over the middle of the fascine or sod in the course below. The interior of the parapet may be revêted with sods, or if the work is to contain artillery, the interior of the parapet, as well as the cheeks of the embrazures, should be revêted with fascines, the ends of the courses in both overlapping each other alternately on each side of the neck of the embrazure.

When a work is commanded by a height in front, the interior must be defiladed by elevating the parapet to such a height, that a line of fire from any arm on the highest visible point of the hill, when it passes

over the crest, may be every where at least eight feet above the terre-plein of the work; or, if this should require a parapet of greater height than can be constructed, the parapet must be elevated as much as possible, and a traverse must be raised across the terre-plein in the place where the line of fire approaches within eight feet of the ground, and its height must be determined by the same means as that of the parapet in the former case. When a work is commanded in reverse, the parapet or traverse must be high enough to defilade the defenders of the banquette opposite the height. Lastly, the banquettes and terre-pleins of ramparts that are commanded, should be formed in planes parallel to the plane of defilement of the crest of the parapet.

The faces of works which are commanded should be directed so that their prolongations may not fall on the heights, lest they should be enfiladed from thence; and, for the same reason, when a line crosses a valley, it should take a concave form towards the enemy, and the heights should be occupied by works into which the prolongations of the faces of the intermediate lines should be made to fall.

Palisades, Trous-de-Loup, and Abattis, are employed as obstacles to the approach of an enemy. The first are used in the covered-way, or in the ditches of the works close to the foot of the counterscarpe, that they may be less exposed to the view of the enemy. For the same reason, when palisades are placed in inclining

positions on the exterior slope of a parapet, they should be kept as low as possible. Trous-de-Loup are placed in the ditch, or on the ground in front of any work. They should be at small distances apart, and in two or more lines opposite each other's intervals. Abattis are employed in the same circumstances as Trous-de-Loup.

An inundation is formed by constructing a dam across a river in places where the ground rises each way from the banks, and its extent in breadth is determined by the form of the ground and the necessity of making it deep enough to prevent the enemy from fording it; but it should not exceed the range of musquet shot, by which he must be prevented from forming rafts on the opposite side. When the inundation is not deep enough to constitute an obstacle to the enemy, oblong pits may be made in two lines, opposite each other's intervals; these being covered by the water, will increase the difficulty of passing it.

Every part of the inundation should be seen from the line, or advanced works should be constructed to give a view of those parts which would be otherwise concealed.

OF THE TIME NECESSARY FOR THE CONSTRUCTION OF A FIELD WORK, THE NUMBER OF WORKMEN, &c.

The number of workmen must be proportioned,—to the time allotted for carrying on the work,—to the

quantity of labour,—and to the number of hands capable of being employed at the same time.

When the ditches are broad the workmen may be posted in two rows; but if narrow, only in one. In the first case, the earth will be thrown by those who are on the outside edge of the ditch to the second row, and by them upon the parapet; for which reason, the second row, that they may keep pace with the first, ought to be twice as numerous. The men should never be placed nearer to each other than two paces or four feet; and two men with spades or shovels should be preceded by one with a pick-axe.

If more than usual expedition be required, one man with a wheel barrow, or basket, may be added, for every six or eight with spades and shovels. A third row of workmen should also be placed upon the parapet, to spread the earth and beat it down, as it is thrown up. When the height of the parapet is considerable, a fourth row must be posted on the berm, to assist in throwing up the earth to the row on the parapet.

In fixing the fascines, gabions, turfs, or sand-bags, three men will be sufficient for every 24 feet of work. They should be provided with two mallets, a saw, and a hand-bill or hatchet.

In order to form some idea of the time in which any description of work may be completed, compute the number of cubic feet of earth to be excavated, thus:—

Multiply the mean breadth of the ditch, or half the sum of the breadths at top and bottom, by the depth, for the number of square feet in the profile; and this product multiplied by the distance between the workmen, in feet, will give the number of cubic feet which each man has to excavate. Then, it being ascertained that, in medium soils, a man can excavate 200 cubic feet of earth in 12 hours, it follows, that if the quantity which each man has to excavate be multiplied by 12, and divided by 200, the quotient will be the time required to raise the work.

The manner of preparing the materials for reveting the slopes, and estimating the quantity for any particular work, may be seen under the words FASCINES, GABIONS, &c. See the word BATTERY.

FRICTION.

The friction produced by one body moving over another while they are pressed together, is caused by the change of figure, which, in consequence of the pressure, the contiguous surfaces of the bodies undergo while in motion. By which, a certain force is required to raise the moving surface over the protuberances of the other.

The following are a few useful results obtained from the experiments of M Coulomb; one body being made to move horizontally on another, and the bodies being pressed together by a certain weight.

I. When the motion is in the direction of the fibres, the surfaces remaining in contact two or three minutes, and having no unguents between them.

The friction of Oak against Oak is equal to $\frac{1}{2\cdot34}$ of the pressure arising from the weight of the upper body.

Of Oak against Fir................ $\frac{1}{1\cdot5}$

Of Fir against Fir................ $\frac{1}{1\cdot78}$

Of Elm against Elm .... $\frac{1}{2\cdot18}$

The friction does not appear to depend on the velocity, but it increases with the time of contact, reaching its maximum in 8 or 10 seconds.

When the direction of the motion is perpendicular to that of the fibres, the friction of Oak against Oak is equal to $\frac{1}{3\cdot76}$ of the pressure.

II. When Oak rubs against Oak, in the direction of the fibres, and with the surfaces greased.

With a pressure equal to

3250 lbs. the friction is equal to $\frac{1}{27\cdot6}$ of the pressure.

850 .... $\frac{1}{23\cdot6}$

250 .... $\frac{1}{18\cdot5}$

50 .... $\frac{1}{7\cdot7}$

The friction increases with the time of contact; for example, when the pressure is 3250 lbs., the friction, immediately on application, is $\frac{1}{27\cdot6}$ of the pressure.

In one minute .... $\frac{1}{7 \cdot 87}$

In one hour .... $\frac{1}{3 \cdot 7}$

In five days .... $\frac{1}{2 \cdot 6}$

III. When the rubbing surfaces are without unguents.

The friction of Iron upon Iron, is $\frac{1}{3 \cdot 5}$ of the pressure.

of Iron upon Brass, is $\frac{1}{4 \cdot 2}$

The friction is independent of the area of the surface in contact, and of the velocity.

IV. When the surfaces are greased, and the pressure is equal to 1650*lbs.*

The friction of Iron on Brass is from $\frac{1}{11 \cdot 0}$ to $\frac{1}{9 \cdot 8}$ of the pressure, and depends but little on the time of contact.

Of Iron on Iron $\frac{1}{10 \cdot 3}$

Of Iron on Oak $\frac{1}{13 \cdot 2}$ in half a second.

$\frac{1}{8 \cdot 25}$ in four hours.

$\frac{1}{4 \cdot 86}$ in four days.

FUZES.

The empty fuzes are made of well seasoned beech. Great precision is necessary in turning them, that the bore may be perfectly cylindrical, and that its axis may exactly coincide with that of the fuze. If these two conditions be not attained, it will be perfectly impossible to produce uniformity in driving.

General Table of Fuzes.

NATURE OF FUZE.	Fuze Diameter.			Compositon.		Quick-match.		Time each fuze burns.	Number one man can drive in a day.
	Below the cup.	At the bottom.	At the cup.	Diameter.	Length.	Length.	Threads in each.		
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	No.	Seconds.	
13-Inch	2·1	1·575	2·47	·5	8·4	17	6	35	25
10 Ditto...........	1·8	1·35	2·13	·438	7·2	14	6	33	25
8 Ditto...........	1·3	1·25	1·78	·375	6·37	12	5	29	30
$5\frac{1}{2}$ Ditto..........	1·1	·825	1·3	·275	4·4	10	3	18	50
$4\frac{2}{5}$ Ditto..........	1·0	·75	1·18	·25	3·5	8	3	15	70
Grenades...........	·8	·6	·9	·2	2·25	3	2		100

The interior diameter of the cup is equal to three times that of the bore; and its depth is equal to one and a h lf of the said diameters.

The thickness of the wood at the bottom of the bore is equal to two diameters.

Composition.

	lb.	oz.
Saltpetre......................	3	4
Sulphur	1	0
Mealed Powder................	1	12

The above proportion of ingredients should be carefully weighed out and mixed; first by rubbing it between the hands for about ten minutes, and then passing it four times through a fine hair sieve.

The following blind-fire composition is sometimes used in driving fuzes, the intention being to deceive the enemy as to the flight of the shell in the night.

Mealed Powder..........................	16 parts.
Wood Ashes	$9\frac{1}{2}$ ditto.

The ashes must, previously to being mixed with the mealed powder, be baked over again, and passed through a fine hair sieve. Potter's earth or clay will produce the same effect as the ashes.

It must be remembered, that if the ingredients be not thoroughly incorporated, the composition will not burn equably; and that upon the goodness of the Fuze the effect of the Shell principally depends.

Table for Driving Fuzes, Nature of Mallet, of Copper Ladles, Dimensions of Drifts, &c.

NATURE OF FUZE.	Iron Drifts, tipped with Brass.					Nature of Mallets.		Nature of Copper Ladles.		No. of blows to each Ladle-full.
	Body.			Handle.						
	Diameter.	Length. First Drift.	Length. Second Drift.	Diameter.	Length.					
	Inches.	Inches.	Inches.	Inches.	Inches.	lb.	oz.	drs.	grs.	No.
13-Inch	·5	9·6	4·889	·9	1·7	2	1	2	0	21
10 do..........	·438	8·2	4·125	·75	1·6	1	10	1	0	18
8 do..........	·375	7·15	3·15	·7	1·5	1	$4\frac{1}{2}$	0	8	15
$5\frac{1}{2}$ do..........	·275	4·875	2·85	·55	1·37	0	14	0	6	13
$4\frac{2}{5}$ do..........	·25	4·0	2·2	·46	·95	0	11	0	4	12
Grenades	·2	2·45	2·45	·425	1·125	0	$8\frac{1}{2}$	0	3	10

In driving the fuzes the principal points to be attended to, are, First :—to put in equal quantities of composition at each time,—which is effected by passing a round piece of cane over the edges of the ladle, to take off the superfluous composition; and, Secondly: —to keep the blows as steady and regular as possible, giving always the same number to each ladleful of composition.

The fuzes are driven up to within half a diameter of the cup, and then gauged. They are then primed with quick-match, and a ladleful of mealed powder is put over it, which must be driven down with thirteen or fourteen strokes of the mallet; the ends of the match are next doubled in, and the cup is filled up with mealed powder moistened with spirits of wine. In two or three days, when the priming is dry, they are completed by placing a circle of cured paper over the cups, after which a cap of brown paper or painted canvas is tied over all.

Rules for computing the Length of Fuze for any given Range.

The 13 and 10-inch Fuzes, of the same length, burn so nearly equal, that one common length answers both, as do the 8, 5½, and 4⅖-inch. Therefore, to find the length of Fuze for any Range, multiply the time of flight by ·22, for the 13 and 10-inch, and by ·24, for the 8, 5½, and 4⅖-inch, which are the decimal parts of an inch each fuze burns in a second.

The following are the Proportions of Materials required for making One Thousand of each Nature of Fuzes.

DESCRIPTION OF MATERIALS.	Common.						Spherical. Common.		Spherical. Mealed Powder.	
	13-In.	10-In.	8-In.	$5\frac{1}{2}$-In.	$4\frac{2}{5}$-In.	Grends	8-In.	$5\frac{1}{2}$-In.	8-In.	$5\frac{1}{2}$-In.
Beech, Clefts..........	200	170	84	40	30	20	20	9		
Tallow.......... lb. oz.	1 0	1 0	0 12	0 8	0 8	0 8	0 8	0 8		
Saltpetre, pulverized, ditto	58 8	46 5	27 10	8 12	3 0	1 6	7 0	6 1		
Sulphur, sublimed, ditto	18 0	14 4	8 8	3 6	1 0	0 7	2 2	1 14		
Mealed Powder, ditto	78 0	58 4	35 8	14 3	5 8	2 12	10 7	8 10	17 8	15 8
Match, Quick, ditto	5 4	4 8	4 0	1 8	1 4	0 12	3 8	2 3	3 8	2 3
Twine, Packers, ditto	0 10	0 $7\frac{1}{2}$	0 7	0 $6\frac{1}{2}$	0 $5\frac{1}{2}$	0 4	0 8	0 6	0 8	0 6
Paper, brown, qrs. shts.						1 12	1 18	1 18	1 18	1 18
Spirits of Wine, qts. pts.	4 1	4 0	2 $0\frac{1}{2}$	1 $1\frac{1}{2}$	1 $0\frac{1}{2}$	1 0	4 0	3 0	4 0	3 0
Cat-gut, lbs. ozs.							0 5	0 5	0 5	0 5
Duck, Russia, $\frac{9}{8}$, yards	$32\frac{1}{2}$	$27\frac{1}{2}$	$17\frac{1}{2}$	$12\frac{1}{2}$	10					
Litharge, lbs. ozs.	0 1	0 1	0 1	0 $0\frac{1}{2}$	0 $0\frac{1}{2}$					
Oil, Linseed, raw, qts. pts.	2 1	2 $0\frac{1}{8}$	1 1	1 0	1 0		0 $0\frac{1}{4}$	0 $0\frac{1}{4}$	0 $0\frac{1}{4}$	0 $0\frac{1}{4}$
Paint, lb. oz. Dry Black, Lamp	0 9	0 8	0 6	0 $3\frac{1}{2}$	0 $3\frac{1}{2}$		0 2	0 2	0 2	0 2
Paint, lb. oz. Dry Red Lead..	0 8	0 7	0 6	0 4	0 4		0 1	0 1	0 1	0 1
Paint, lb. oz. In Oil, White Lead	10 0	9 0	6 0	4 0	4 0					
Turpentine, Spirits of, pts.	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$		$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$

GABIONS

Are a kind of cylindrical baskets, without bottoms, and are made of various sizes, according to the purposes for which they are intended.

Those 3 feet high, and 2 feet in diameter, are the most convenient for almost every description of works; they are made with the least trouble, and are most easily carried. The stakes or pickets for these should be from 1 to 1½ inches thick, and about 4 feet long. Large gabions, 6 feet high, and from 3 to 4 feet in diameter, are sometimes used :—they are troublesome to make, and require two men to carry them.

There is also a smaller description of gabions, in the form of a frustum of a cone. These are generally 1 foot high, 12 inches in diameter at the top, and 9 inches at the bottom; they are used in sieges to form loop-holes on the crest of the parapet.

PROCESS OF MAKING GABIONS.

It may be as well to premise, previously to commencing this work, that an odd number of stakes or pickets should, especially in the smaller description of gabions, invariably be employed; and that their distance apart should never exceed 9 inches.

To make the Gabions.

1. Make choice of a level piece of ground for this purpose, beat it firm with an earth setter, or other con-

venient implement, and drive a picket of about 9 inches long into it, to mark the centre of the intended gabion.

2. Prepare a piece of strong twine, or cord, by doubling it to half the diameter of the proposed gabion; then place one end of this loop over the picket, marking the centre, and, with a sharp pointed stake through the other extremity, use it as a radius, and describe the circumference of a circle upon the ground, to represent the foundation.

3. The number of pickets, and their distance apart, for each particular gabion, must, of course, depend upon its diameter. The following general rule applies to all cases :—

Multiply the given diameter by 22, and divide the product by 7, and this quotient again by such odd number as will give a quotient not exceeding 9. Then the last divisor will be the number of pickets, and the last quotient their distance apart.

Thus, for example, let it be required to find the number of pickets, and their distance apart for a gabion of 20 inches diameter?

Here, $\frac{20 \times 22}{7} = 62\frac{6}{7}$ or 63 inches nearly,

Then, $\frac{63}{9} = 7$ inches.

Hence, 9 will be the number of pickets required, and 7 inches their distance apart.

4. The pickets are next to be driven into the ground, at their proper distances, in the above described circle, and the twigs or wattles worked gradually round them, commencing at the bottom, and passing each twig alternately, inside one picket, and outside the next, and thus continuing till the work is finished.

Four men are usually employed upon each gabion, with a mallet, bill-hook, and two axes. Two of them to collect and prepare stuff, while the other two form the gabion.

A gabion 3 feet high, and 20 inches in diameter, should not occupy more than half an hour in making.

GABIONNADE.

A term employed to denote a work thrown up in haste. A parapet that is made of gabions is termed a parapet *en gabionnade*.

GALLERY.

A passage of communication to that part of a mine where the powder is lodged. See the word MINES.

GENOUILLERE.

The genouillère is that part of the parapet of a battery which lies immediately under the embrazure. The height of the genouillère above the platform, depends upon that of the gun-carriage.

Weight, Dimensions, &c. of Grape-Shot.

	NATURE OF ORDNANCE.	Shot. Weight.	Shot. No. in each.	Tompeons. Pin. Length.	Tompeons. Pin. Diameter	Tompeons. Bottom. Thickness	Tompeons. Bottom. Diameter	Tompeons. Weight.	Plates. Diameter.	Plates. Thickness.	Plates. Weight of three.	Length of Line.	Canvas. Length.	Canvas. Breadth.	Total Weight.
		lb. oz. dr.		In.	In.	In.	In.	lb. oz. dr.	In.	In.	lb. oz. dr.	Ft. In.	Ft. In.	Ft. In.	lb. oz. dr.
New Pattern.	32-Prs.	3	9					4 3 4	6·15	·41	6 4				36 5 12
	24 Do.	2	9					3 9 12	5·56	·41	5 6				25 9 4
	18 Do.	1 8	9					3 12	5·05	·31	3 3 8				19 4
	12 Do.	1	9					2 2 8	4·44	·28	2 6 4				13 3 8
	9 Do.	13 2	9					1 4 12	4·03	·24	1 12				10 6 12
	6 Do.	8	9					14 12	3·5	·22	1 4				6 6 8
Old Pattern.	42-Prs.	4	9	9·15	·58	·61	6·68	6 9 4				10	1 4·5	1 6·5	42 9 4
	32 Do.	3	9	8·31	·55	·55	6·10	5				8 10	1 2·5	1 5	32
	24 Do.	2	9	7·26	·7	·48	5·54	4 6				7 2	1	1 3·5	22 6
	18 Do.	1 8	9	6·6	·63	·44	5·03	3 6				6 11	1	1 1·5	16 8 6
	12 Do.	1	9	5·76	·55	·38	4·4	1 15 14				6 4	10·5	1 1	10 15 14
	9 Do.	13 2	9	5·40	·4	·36	4·0	1 10 12				6	10·25	11	9 14
	6 Do.	8	9	4·57	·44	·3	3·48	1 8				5 6	8·5	9·75	5 8 8
	4 Do.	6	9	4·15	·28	·27	3·05	8 10				5	7·75	8·5	4 14 13
	3 Do.	4	9	3·63	·35	·24	2·77	6 10				4 6	7·75	8	2 10 10

The invention of the new pattern grape is attributed to Mr. Caffin, a clerk in the Royal Laboratory, but erroneously. The merit of this invention is due to Major-General Shrapnel, who proposed it in 1793, and a drawing of it, bearing that date, is to be seen in the office of the draughtsman of the Royal Military Repository.

The following Proportions of Materials are required to complete One Hundred Grape-Shot of each Nature.

	Nature of Ordnance.	Tompeons.	Plates (Iron).	Line. Length.		Line. Circumference.	Canvas.	Thread.		Shot.	No. one man can complete in one day.
				Ft.	In.	In.	yd	oz.	drs.	No.	
Old Pattern.	42-Pounder	100		1000		·96	39	2	8	900	15
	32 Do.	100		883	4	·85	34	2	8	900	15
	24 Do.	100		716	8	75	27	2	4	900	20
	18 Do.	100		691	8	·69	22	2	4	900	20
	12 Do.	100		633	4	·6	15	2	4	900	25
	9 Do.	100		600		·56	14	2		900	25
	6 Do.	100		500		·47	11	2		900	25
	4 Do.	100		500		·41	9	1	8	900	30
	3 Do.	100		450		·38	8	1	8	900	30
New Pattern.	32-Pounder	100	300							900	
	24 Do.	100	300							900	
	18 Do.	100	300							900	
	12 Do.	100	300							900	
	9 Do.	100	300							900	
	6 Do.	100	300							900	

OBSERVATIONS ON FIRING GRAPE AND CASE-SHOT.

The balls of grape and case-shot, when discharged from a gun or other piece of ordnance, are observed at first to take a diverging direction, and for a certain distance to form a species of irregular cone; of which

the base is towards the object fired at, and the vertex towards the gun.

It is impossible from theory alone to determine the direction that each individual ball takes after the case is broken, since the contact of the balls, and their reciprocal pressures at the discharge, and at the commencement of their divergence are unknown. It should therefore be ascertained as far as possible experimentally.

From a series of experiments, conducted with the utmost care and attention, the following results have been obtained.

1. The conical figure is preserved to a certain distance, after which it is entirely lost.

2. The distance between the point of formation of the cone, and that at which it begins to lose the regularity of its figure, depends upon the size of the balls and their initial velocity.

3. At equal distances, balls propelled from guns of the ordinary length, diverge much less than balls of the same weight and diameter, propelled from shorter guns with the same charge.

4. When the balls are ranged in the case or cylinder in regular order, or in tiers, they diverge much less than when put in hap-hazard.

5. When a gun is loaded with case or grape-shot, the line of direction should be rather over than under

the object; but this must depend upon the extent of the range.

The proportions of materials in the foregoing table are the neat quantities required, except for the canvas, thread, and length of line, in each of which a small allowance is made for waste.

GRAVITY.

The term gravity denotes the natural tendency or inclination of all bodies towards the centre of the earth, and is divided into *Absolute* and *Specific.*

Absolute gravity denotes the whole force with which a body tends downwards.

Specific gravity, the relative or comparative gravity of any body, in respect to that of another body of equal bulk or magnitude. It further denotes, that gravity or weight which is peculiar to each species or kind of body, and by which it is distinguished from all other species or kinds.

In this sense a body is said to be specifically heavier than another, when under an equal bulk or magnitude, its weight is greater than that other; and reciprocally, the latter is said to be specifically lighter than the former.

TABLE OF THE SPECIFIC GRAVITIES OF SEVERAL SOLID AND FLUID BODIES.

Air, in a mean state	1·232	Apple-tree	793
Alder	800	Ash, the trunk....	845

Bay-tree	822
Beech	852
Box-wood	1030
Brass, cast	8000
Brick	2000
Campechy-wood	913
Cedar, Wild	596
Cedar, Palestine	613
Cedar, Indian	1315
Cedar, American	561
Charcoal	
Cherry-tree	715
Citron	726
Clay	2160
Coal	1250
Cocoa Wood	1040
Copper	9000
Cork	240
Cypress, Spanish	644
Earth, common	1984
Ebony, American	1331
Ebony, Indian	1209
Elder-tree	695
Elm	671
Filbert-tree	600
Fir, Male	550
Fir, Female	498
Flint	2570
Glass, Crystal	3150
Glass, Common green	2600

Gold, Fine	19640
Gold, Standard	18888
Gun-Metal	8784
Granite	3000
Gun-powder, Solid	1745
Gun-powder, Closely shaken	958
Gun-powder, In a loose heap	868
Hazel	600
Iron, Wrought	7645
Iron, Cast	7425
Ivory	1825
Jasmin, Spanish	770
Juniper-tree	556
Lead	11325
Lemon-tree	703
Lignum-vitæ	1333
Linden-tree	604
Mahogany	1063
Maple	750
Marble	2700
Mastic-tree	849
Medlar ditto	944
Mulberry, Spanish	897
Nitre	1900
Oak	950
Olive tree	927
Orange ditto	705
Pear ditto	661
Pitch	1150

Platina, Pure	23400	Steel	7850
Plum-tree	785	Stone, Common	2520
Pomegranate ditto	1354	Sulphur	1810
Poplar	383	Tar	1015
Quick-silver, Pure	23400	Tin	7320
Quick-silver, Common	14000	Vine	1327
Quince-tree	705	Walnut	671
Rosin	1100	Water, Common	1000
Sand	1520	Water, Rain	1000
Sassafras	482	Water, River	1009
Silver, Fine	11091	Water, Sea	1030
Silver, Standard	10535	Willow	585

These numbers being the weights of a cubic foot, or 1728 cubic inches of each of the bodies in avoirdupois ounces, the *quantity* in any other *weight*, or the *weight* in any other *quantity*, may be readily found by the following rules.

To find the Magnitude of any Body from its Weight.

Say, As the tabular specific gravity of the body,
Is to its weight in avoirdupois ounces;
So is one cubic foot, or 1728 cubic inches,
To its content in feet or inches respectively.

Example. How many cubic inches of gunpowder are there in a closely shaken mass weighing one pound?

Here it will be,

As 958 : 16 : : 1728 : 28·7 cubic inches nearly. The content required.

To find the Weight of a Body from its Magnitude.

Say, As one cubic foot, 1728 cubic inches,
Is to the content of the body;
So is the tabular specific gravity,
To the weight of the body.

Example. The walls of Balbeck are built of marble, and one of the blocks is 63 feet long, 12 feet in breadth, and the same in thickness, required its weight?

Here, $63 \times 12 \times 12 = 9027$ cubic feet. The content of the block.

Then it will be,

As 1 : 9072 : : 2700 : 24494400 oz. or $683\frac{7}{16}$ tons. The weight required.

FORCE OF GRAVITY.

The earth being of an oblate spheroidal form, the force of gravity will be greater near the poles than at the equator; and it is measured by the velocity generated in one second of time by a body falling from a state of rest. Let this velocity be expressed by 2 g, where g represents the space a body falls through during one second, then $f \propto g$.

But when a body falls by the force of gravity, the spaces descended are proportional to the squares of the generated velocities. Therefore, let a body fall through equal spaces, (s), by two different gravitating forces, represented by f and *f*, or by g and *g*.

Then, $\mathrm{g} : (2\,\mathrm{g})^2 :: \mathrm{s} : 4\,\mathrm{s}\,\mathrm{g}$; and $g : (2\,g)^2 :: s : 4\,s\,g$.

But $4\,\mathrm{s}\,\mathrm{g}$ and $4\,s\,g$, which represent the velocities generated after describing equal spaces, are, evidently, to each other as g to g; that is, as the gravitating forces. Therefore, $f \propto v^2$ when the spaces are equal.

Again, the velocity of a pendulous body, vibrating by the force of gravity, is equal to that acquired by a body falling through the versed sine of the arc of vibration; and if two pendulums are of equal length and describe equal arcs, the versed sines are equal, and f is proportional to the square of the velocity of the pendulum. But the number of vibrations performed in equal times is proportional to the velocity; therefore, the force of gravity in different places on the earth's surface is proportional to the square of the number of vibrations performed, by equal pendulums, in equal times.

The increase of the force of gravity from the equator towards the poles, is proportional to the square of the sine of the latitude; and according to Captain Sabine's experiments, the whole increase of the force of gravity at the pole beyond that at the equator is equal to ·20227, the force at the equator being expressed by unity.

CENTRE OF GRAVITY.

The centre of gravity of a terrestrial body or system

of bodies, is that point through which if a plane be made to pass, and that plane be brought to a vertical position, the sum of the actions of gravity upon all the points or bodies situated on one side of the plane is equal to the sum of the actions of gravity upon all the points on the other side.

As the gravitating principle acts in lines passing through any given point and the earth's centre, and as these lines may be considered parallel to each other without sensible error, within the limits of any system of bodies connected together for mechanical purposes, it follows that the centre of gravity of any body, or system of bodies, may be found by the theory of parallel forces.

From that theory it will follow that the centre of gravity of a right line is in the middle of its length; because the sum of the actions of gravity upon all the points on each side of its middle point will be equal to each other.

And for a like reason, the centre of gravity of a circle, of a regular polygon, of a prism, of a cylinder, of a sphere, or of any regular body, is in its centre.

The centre of gravity of a triangle is found by bisecting any two of its sides, and drawing lines from the points of bisection to the opposite angles, the intersection of these lines will be the centre of gravity required. For, suppose the triangle to be composed of an infinite number of right lines parallel to one of its sides, the centre of gravity of each line being in its

middle, that of the whole figure will be somewhere in a line bisecting all those parallel lines, which will be the line drawn from the middle of one side to the opposite angle. For the same reason, the centre of gravity of the whole will be somewhere in a line drawn from the middle of another side to its opposite angle; therefore, it will be in the intersection of two such lines.

The centre of gravity of two bodies is, from the theory of parallel forces, in a line joining the centre of gravity of both bodies, and is at a distance from each, inversely proportional to the masses or weights of the bodies respectively.

Thus, the common centre of gravity of two bodies, A and B, may be found by the following proportion, viz.—the sum of the weights of A and B, is to the weight of A, as the distance of the centres of gravity of A and B, is to the distance of the common centre of gravity of the two bodies from that of B.

The centre of gravity of any irregular figure may be found by dividing it into triangles, finding the centre of gravity of each triangle separately, joining any two of those centres by a right line, and finding the common centre of gravity of those two triangles by the proportion just mentioned; expressing the weights of the triangles by their areas which are proportional to their weights, then joining this centre of gravity, and that of a third triangle, and finding the common centre of gravity of the three triangles as

before, and so continuing till the centre of gravity of the whole figure is found.

The centre of gravity of any plane surface may be found experimentally thus:—place the surface in two different positions on the edge of a prism, and move it about till it is in equilibrio in both positions; then, draw lines upon the surface, coinciding with the edge upon which it rested in equilibrio, and the intersection of those lines will be the centre of gravity required.

In the same way the centre of gravity of a solid body may be found by balancing it in three different positions on the edge of a prism, and imagining vertical planes to pass through the lines on which the body is in equilibrio; for then the centre of gravity of the body will be the point of the common intersection of all the three planes.

GREASE.

The composition used for greasing the axle-trees in the artillery service, is composed of equal parts of tallow and the coarser kinds of sweet oil, which are melted together and made up into kegs of 28lbs. weight each.

GRENADES.

Hand-grenades may be thrown to the distance of 13 fathoms. See the word SHELLS.

Weight and Dimensions of Brass and Iron Guns.

Nature of Guns.		Calibre. Inches.	Length of Gun, in Calibres.	Length of Gun, in Inches.	Length of Bore, in Calibres.	Length of Bore, in Inches.	Weight. cwt.	qr.	lb.	Proportion between the Shot and Gun.
Brass.	12-Prs. Medm.	4·623	17·0	78·6	16·126	74·55	18			168
	12-Prs. Light.	4·623	13·0	60·079	12·245	56·61	12			112
	9 Ditto	4·2	17·0	71·4	16·129	67·74	13	2		168
	6 Ditto	3·668	22·9	84·0	21·906	80·35	12			224
		3·668	19·629	72·0	19·0	69·692	9	1	2	173
		3·668	16·358	60·0	15·669	57·47	6			112
	3 Ditto	2·913	22·717	72·0	22·125	64·45	6			226
		2·913	16·478	48·0	15·791	46·0	3			112
		2·913	12·358	36·0	11·672	34·0	2	1		84
	1 Ditto	2·019	29·718	60·0	28·718	59·981	2	2	11	291
Iron.	10-Inch	10·0	9·0	90·0	8·86	88·0	56			89·6
	68 Pounder	8·05	10·0	80·5	10·0	80·5	50			82·35
	42 Ditto	7·018	16·24	108·5	15·24	106·982	65	1		174
	32 Ditto	6·41	17·8	108·5	16·723	107·2	55	2	24	195
		6·41	14·976	96·0	14·0	89·74	47	2	24	167
	24 Ditto	5·823	19·577	108·5	18·458	107·41	50		16	234
		5·823	18·546	108·0	17·42	101·45	47	2	8	224
		5·823	16·486	96·0	15·37	89·5	43	2		203
		5·823	15·45	84·5	14·416	83·95	40		8	187
	18 Ditto	5·292	20·4	108·0	19·22	101·75	42		12	262
		5·292	18·13	96·0	16·95	89·74	37	2	12	234
	12 Ditto	4·623	23·36	108·0	22·113	102·23	33	3	24	317
		4·623	22·063	96·5	20·81	96·221	33			308
		4·623	19·467	84·5	18·22	84·25	29	2	8	276
	9 Ditto	4·2	25·714	108·0	24·4	102·487	31		2	386
		4·2	24·285	96·5	23·0	96·48	28	2	3	355
		4·2	21·42	84·5	20·13	84·435	26		4	324
		4·2	20·0	84·0	18·68	78·48	24	3	27	311
	6 Ditto	3·668	27·808	96·5	26·4	96·957	23		4	430
		3·668	26·17	96·0	24·79	90·956	22		2	411
		3·668	24·536	84·5	23·162	84·96	21			392
		3·668	22·92	84·0	21·52	78·952	20		4	374
		3·668	21·265	72·5	19·89	72·96	18			336
		3·668	19·629	72·0	12·25	66·97	17		4	316

GUN-METAL.

This metal is a compound of tin and copper, in the proportion of eight or ten pounds of the former, to a hundred pounds of the latter. The property of tin being to harden and give solidity to the compound, the largest proportion of it is used for mortars, as they require a greater degree of hardness than guns.

To find the Quantities of Two Ingredients in a given Compound.

Take the three differences of every pair of the three specific gravities, viz.—the specific gravity of the compound and of each ingredient, and multiply each specific gravity by the difference of the other two.

Then say,

As the greatest product,
Is to the whole weight of the compound;
So is each of the other two products,
To the weights of the two ingredients.

Example. The specific gravity of a compound of tin and copper being 8784, its weight 112lbs., and the specific gravities of the tin and copper 7320, and 9000 respectively, required the quantity of each ingredient?

First,

$8784 - 7320 = 1464$. The difference between the specific gravities of the compound and tin.

9000—8784 = 216. The difference between the specific gravities of the compound and copper.

9000—7320 = 1680. Do. copper and tin.

Second,

8784 × 1680 = 14,757,120. The product of compound, and difference of tin and copper.

7320 × 216 = 1,581,120. Do. do. of compound and copper.

9000 × 1460 = 13,176,000. Do. do. of compound and tin.

Then, 14,757,120 : 112 : : 13,176,000 : 100 lbs. The quantity of copper.

And, 14,757,120 : 112 : : 1,581,120 : 12 lbs. The quantity of tin.

GUNNERY (Parabolic Theory of).

When a shot is discharged from a gun, in a non-resisting medium, by the expansive force of gunpowder, it would, by the laws of impulsive force, move for ever in a rectilinear direction with an uniform velocity, if it were not for the action of gravity. But in every case, except that in which the gun is fired in a direction perpendicular to the horizon, the power of gravity continually deflects the shot from the rectilinear direction which the force of the powder alone would cause it to take, and compels it to describe a curve

line tending towards the earth, and to which curve the axis of the gun is a tangent. And the place of a shot at any time will be found by compounding the motion in the direction of the tangent during that time, with the motion which would take place by the action of gravity alone in the same time.

Now, the spaces described by the force of the powder alone in the direction of the axis of the gun would be proportional to the times of describing them; but the force of gravity acting always perpendicularly to the horizon, and being accelerative, the deflections of the shot, from the rectilinear direction, may be conceived to take place in parallel lines, making a constant angle with the axis of the gun produced; and the lengths of those lines will be proportional to the squares of the times of describing them, which times, by hypothesis, are equal to the times of describing the spaces on the tangent between the gun and the line of direction of gravity. Therefore, the deflections from the tangent by the action of gravity, are proportional to the squares of the corresponding spaces on the tangent; and this relation of the spaces is a property of the parabola. Therefore, the trajectory of the shot, if its motion were not resisted by the air, would be a parabolic curve.

Consequently, knowing the initial velocity of the shot, and the position of the axis of the gun, the form of its trajectory may be traced, and the extent of its range determined; for the velocity, multiplied by any

given time, will express the space which the shot would describe, by the force of the powder alone, in that time, on the axis of the gun produced. Then, if a vertical line be drawn through the extremity of this space, the deflection produced by gravity may be found by multiplying the square of the given time by $16\frac{1}{12}$ feet, the space a body falls through in one second; and this length being set off from the tangent upon the said vertical line, will give the place of the shot, in the curve, at the given time. But the extent of the horizontal range may be determined as follows.

Find the space through which a body must fall to obtain a velocity equal to the initial velocity of the shot, and on a line equal to this, as a diameter, describe a semi-circle. Then, if a line be inscribed in this semi-circle from one extremity of the diameter, and making an angle with it equal to the elevation of the gun, and a perpendicular be let fall upon the diameter from the place where the line intersects the circle, it will be equal to one-fourth of the range.

If the range be bisected by a perpendicular, which also cuts the axis of the gun produced, the middle of this line between the range and the axis will be the vertex of the parabola, or highest point of the trajectory.

The space due to the initial velocity is called the impetus. See also the words Projectiles and Trajectory.

Table of the First Grazes with Field Guns and Howitzers:—

Guns.			Howitzers.		
Elevation.	Light 6, and Heavy 3-Prs.	12, 9 and Heavy 6 Pounders.	Elevation.	$5\frac{1}{2}$ Inch and 24-Prs.	$4\frac{2}{5}$ Inch and 12-Prs.
Deg.	Yards.	Yards.	Deg.	Yards.	Yards.
P. B.	200	300	P. B.	150	
$\frac{1}{4}$	300	400	1	300	
$\frac{1}{2}$	400	500	2	450	
$\frac{3}{4}$	500	600	3	600	
1	600	700	4	750	
$1\frac{1}{4}$	650	775	5	850	
$1\frac{1}{2}$	700	850	6	950	
$1\frac{3}{4}$	750	925	7	1050	
2	800	1000	8	1150	
$2\frac{1}{4}$	850	1050	9	1200	
$2\frac{1}{2}$	900	1100	10	1250	
$2\frac{3}{4}$	950	1150	11	1300	
3	1000	1200	12	1350	

GUN-POWDER.

The following are the relative Proportions of Ingredients for making Gunpowder, according to the practice of different countries.

Countries.	Nitre.	Charcoal.	Sulphur.	Total.
England	75	15	10	100
France	75	15·5	9·5	100
Sweden	75	16	9	100
Russia	70	18·5	11·5	100
Austria	76	13	11	100

The explosive power of the composition depends, fundamentally, upon the quantity of elastic gas permanently generated, the rapidity of the inflammation, and the degree of heat to which it is raised. The quantity of gas depends, almost entirely, upon the quantity and purity of the charcoal, by the combustion of which it is produced :—the nitre being the cause of that combustion, and furnishing one part of the generated gas from its own decomposed acid, as it does the other by converting the charcoal into carbonic acid. The sulphur promotes the rapidity of inflammation, and, by its heat, expands the gas at the moment of explosion.

The elastic fluid obtained by the explosion of Gunpowder, is composed of—

Carbonic Acid Gas	49 parts
Azote	34
Hydro Carbonate	10
Nitrous Acid Gas	5
Sulphurous Acid Gas	2

MODE OF PROVING GUNPOWDER.

The first examination of powder is by rubbing it between the hands, for a few seconds, to find whether it contains any irregular hard lumps. The second is by blasting about two drachms of it upon a copper-plate, and comparing it with the good qualities of an approved sort; in this proof it should not emit any sparks, nor leave any beads or foulness on the copper. It is then examined, as to its strength, by the eprouvettes as follows:—

1. In projecting a 68-pounder iron shot from an 8-inch Gomer mortar, at 45 degrees elevation, with a charge of four ounces. In this proof powder, new from the mills, must give a range of not less than 380 feet; and powder that has been issued and returned into store, or regenerated and restoved powder, a range of not less than 350 feet.

2. By the gun eprouvette with a charge of two ounces. With the first of the above powders the index of the eprouvette must describe an arc of 21 degrees; and with the other descriptions, an arc of not less than 20 degrees 30 minutes.

The proof of fine-grained, or small-arm powder, is with a charge of two drachms from a carbine barrel, to perforate, with a steel ball, a certain number of half-inch elm boards, wetted and placed three-quarters of an inch asunder, the first being 39 feet 10 inches from the mouth of the barrel. The best powder gene-

rally propels the ball through 15 or 16, and the restoved powder through from 9 to 12 of these boards.

This powder is likewise submitted to proof by the gun eprouvette, with a charge of two ounces, and the arcs described should be—with powder new from the mills, not less than 26 degrees; and with restoved, and all other descriptions of powder, not less than 24 degrees.

The last trial of powder is by exposing about one pound of each sort, accurately weighed, to the atmosphere, for 17 or 18 days; during which time, if the materials be pure, it will not increase at all considerably in weight, by attracting moisture from the air. In this exposure, 100 pounds of good powder should not imbibe more than 12 ounces of moisture, or somewhat less than one per cent.

Powder Marks.

The different sorts of powder are distinguished by the following marks on the heads of the barrels.

L. G.	Large Grain.	Marked in Red.
F. G.	Fine Grain.	Marked in Red.
R. A.	For Rifle Arms.	
L. G.	Large Grain.	Marked in Blue.
F. G.	Fine Grain.	Marked in Blue.
R. S.	Restoved.	

The Red L. G., or F. G., denotes powder made entirely from cylinder charcoal. The Blue L. G., or F. G., powder made from pit-coal.

GYNS.

Dimensions of Triangle Gyns.

Large.	Cheek or Pry-pole,	20 ft. 6 in. long.	
	Windlass,	6 ft. 9 in. long,	9 in. square.
	Rack,	0 12,	dia. ·25 of an inch thick.
Small.	Cheek or Pry-pole,	16 ft. 3 in. long.	
	Windlass,	5 ft. 11 in. long,	8 in. square.
	Rack,	0 12,	dia. ·25 of an in. thick.

GYRATION (Centre of).

When a body revolves about an axis by a force applied at any point, there is a point in which, if all the matter of the body be collected, the same moving force applied at the former point, will cause the latter point to revolve with the same angular velocity that the body revolves. This point is called the centre of gyration.

The momentum with which any particle in the body resists the moving force, is equal to the mass of that particle multiplied into the square of its distance from the axis of motion; therefore, the sum of the momenta of all the particles of the body may be found.

Again, the whole body being supposed to be collected in the centre of gyration, its momentum at that point is equal to the mass of the whole body, multiplied into the square of the distance of that point from the

axis of motion. And these momenta must be equal, in order that equal angular motion may be produced by the action of the moving force in both circumstances. Therefore, from the equation thus formed, the unknown quantity, which is the distance of the centre of gyration from the axis of motion may be found. This term is found to be a mean proportional between the distances of the centre of gravity and centre of percussion, or of oscillation from the axis of motion.

When a strait line revolves about one of its extremities, the distance of the centre of gyration from the same extremity, is equal to the length of the line multiplied into $\sqrt{\frac{1}{3}}$.

When a circle or cylinder revolves about its centre or axis, the distance of the centre of gyration from that centre or axis, is equal to the radius multiplied into $\sqrt{\frac{1}{2}}$.

When a sphere revolves about one of its diameters, the distance of the centre of gyration from that of the sphere, is equal to the radius multiplied into $\sqrt{\frac{2}{5}}$.

See the word PENDULUM.

HAIR-CLOTH.

Length, 14 feet 6 inches. Breadth, 11 feet. Weight, 36lbs.

HAND BARROWS.

Length, 5 feet 3 inches. Breadth, 2 feet. Weight, 19lbs.

HAND-SPIKES.

Length, 5 feet. Diameter at top 1·25 inches; bottom 2·75 inches square. Length of square, 1 foot 9 inches. Weight of ten, 64lbs.

Besides the above, there is a longer description of hand-spikes, as follows:—Length, 6 feet. Diameter at top, 1·5 inches; bottom, 3 inches square. Length of square, 2 feet. Weight of ten, 100lbs.

HARNESS.

For Men—One set for 6 men. Length, 11 feet. Weight, 21lbs.

For Horses—Wheel harness for a pair of horses.

Riding set, with head-collar and chain, nose-bag, and forage-cord	4st.	9lbs.
Driver in complete marching order......	10	12
Driver's coat............................	0	6
Total weight carried by the riding horse	15	13

Leading set, with head-collar and chain, nose-bag, and forage-cord	4st.	5lbs.
Driver's kit complete, except the brushes and bag, which are carried on the riding horse	1	13
Total weight carried by the lead horse......	6	4

The appointments of a non-commissioned officer, or gunner of horse artillery, comprising the saddle, bridle, &c. complete, with blanket, head-collar, and chain, nose-bag and forage cord, weigh........	2st.	12lbs.
The man's kit, complete	2	12
The man, in complete marching order	13	2
Total weight the horse carries......	18	12

A Light Dragoon horse, mounted and accoutred complete, carries 2 cwt. 1 qr. 14lbs.; and it is curious to remark, that a heavy dragoon horse, under similar circumstances, carries only 2 cwt. 1 qr. 11lbs.

HORSES.

The average weight of horses is about 9 cwt. 1qr. An allowance of 27 square feet, is generally made for each horse standing at picket; or 3 feet in breadth and 9 feet in depth.

Horses for the artillery service should never be less than 14½ hands high, and the contractor is obliged to furnish them of that height for Government. A horse should never be made to draw more than 3 cwt. besides the weight of the carriage; but even this is too great a burthen for the very inferior description of animals that have been latterly provided for this service.

With great burthens, less weight must be allowed for each horse to draw, than with medium burthens; as it

cannot be supposed that, of a team of eight horses, the leaders can draw so much as the horses nearer the carriage; and the disadvantage must increase in proportion as the team lengthens.

A team of 4 horses	may draw	6 cwt. each.	Total 24 cwt.
6	ditto	5 ditto	30
8	ditto	4 cwt. 2 qrs.	36
12	ditto	4 ditto	48

These weights include those of the carriages. It is usual, however, in heavy carriages, to reckon all their weight, exceeding 12 cwt., as part of the load.

The following horses are required for Field Artillery on Foreign Service.

The 18-pounder and 8-inch howitzer require, each..................................	10 horses.
The 12, 9, and heavy 6-pounder, and 24-pounder, and $5\frac{1}{2}$-inch howitzer, each....	8 ditto.
The light 6 and heavy 3-pounder gun, 12-pounder howitzers, and all other carriages belonging to a field battery, each	6 ditto.

ACTIVE STRENGTH, OR ANIMAL ENERGY, AS OF MEN AND HORSES.

The force obtained by means of animal agency, evidently varies, not only in different species of animals, but also in different individuals of the same species. And this variation depends, first:—on the particular

constitution of the individual; and, secondly:—upon the particular dexterity acquired by habit. It is plain, therefore, that such a variation cannot be subjected to any law, and that there is no expedient to which we can have recourse, but that of seeking mean results.

M. Coulomb, in estimating the strength of men and animals, expresses the quantity of action produced by their labour, by the product of the load they can carry, multiplied into the distance to which they can convey it in one day.

When a man travels unloaded, his quantity of action, that is, the product just mentioned, is found to be a maximum; but the useful effect is nothing. If we place a burthen upon him, he produces a certain effect, though his real quantity of action is diminished, and the greater the burthen the less is his action, till, at length, when the load amounts to about 3 cwt., or twice the man's own weight, he cannot move; therefore, his action and effect are both nothing. Between these extremes, there is a certain load which will give the maximum of useful effect.

I. When a man travels on a horizontal road for several days consecutively without a load, he can easily walk 31·07 miles in a day; and this multiplied into the weight of the man, which may be estimated at 160 lbs., gives 4971 lbs. for the daily quantity of action furnished by him under those circumstances. And this is expressed by 4971 lbs. carried one mile per day.

When a certain load is added to the weight of the man, the product of the whole into the distance he can convey it during one day, will be less than that obtained above, and, consequently, will express a smaller quantity of action. M. Coulomb supposes the loss of action to be proportional to the load (and estimates it at 25 times its weight); and, on that principle, he obtains the following equation for the useful effect of the labour, viz.—the sum of the weights of the man and load multiplied into the distance he can convey it, is equal to the difference between the quantity of action furnished by a man unloaded, and the quantity lost by the load. The results of experiment being substituted in this equation, we from thence determine the maximum of useful effect to be obtained when the man carries a load of 135 lbs. besides his own weight. With this he can walk 10 miles per day, and hence the useful effect is expressed by 1350 lbs. carried one mile per day.

But when a man carries a load to a certain distance on a horizontal road, and then returns unloaded for a new burthen, the maximum of useful effect is obtained when that load is 143lbs; this he can convey 7 miles per day, and hence the effect is expressed by 1001 lbs. carried one mile per day.

II. When a man, unloaded, ascends an easy stair, he can go in one day to the vertical height of 1·82 miles. This multiplied by the weight of the man, viz. 160 lbs. gives 291 lbs. for the quantity of action fur-

nished, which is expressed by 291 lbs. raised vertically to the height of one mile per day. And, by employing the principle before stated, it will be found that the maximum of useful effect produced, when a man ascends stairs, is obtained when he is loaded with 123·5 lbs. besides his own weight;—with this he can ascend to the vertical height of 0·66 miles per day. Therefore his useful effect will be 81·5lbs raised one mile vertically per day.

The following are some useful results obtained in similar ways:—

1. A man carrying a load in a wheel barrow, on horizontal ground, produces an useful effect equal to 1480lbs. carried one mile per day.

2. A horse carrying a soldier and his equipments, weighing together 2 cwt. can go 25 miles on a horizontal road daily; therefore his useful effect in this respect may be expressed by 5600lbs. carried one mile per day.

3. A man digging with a spade, produces an useful effect equal to 90lbs. raised to the height of one mile, vertically, per day.

4. A man turning a cylinder by a winch, produces an effect equal to 168lbs. raised to the height of one mile, vertically, per day. But, when two men are employed together to turn a cylinder with two handles, at right angles to each other, the useful effect produced by each man is equal to 196lbs. raised as before.

5. The force of a man in pulling or thrusting horizontally, is estimated at about 30lbs.; and, in these circumstances, he can move with a velocity of 1½ miles per hour.

6. A soldier loaded, with from 45 to 60lbs. can march 12 miles daily, and, if we add to those loads the weight of the man, viz. 160lbs., his daily action is equal to from 2600 to 2800lbs. carried one mile per day.

7. A man marching in a mountainous country, with a load, can produce a daily quantity of action equal to 203lbs. raised one mile.

8. A cart-horse can draw 326lbs. through 25 miles daily on a horizontal road; therefore his useful effect, in this respect, may be expressed by 8150lbs. carried one mile daily.

HORSE SHOES.

There are four sizes of horse-shoes in the service; the fourth, or smallest size, being intended for mules. The following are the weights of a set of each size :—

	lb.	oz.
Largest size	4	10
Second ditto	4	6
Third ditto	3	10
Fourth ditto........................	2	14

The average weight of a box containing twenty sets, with a triple proportion of nails, is about 107 lbs.

HOWITZERS.

Weight and Dimensions of Brass and Iron Howitzers.

	Nature of Howitzer.	Calibre.	Length of				Weight.	Chamber.		
			Howitzer.		Bore in			Length.	Diameter.	
		Inches.	Calibres.	Inches.	Calibres.	Inches.	cwt.qr.lb.		Superior.	Inferior.
Brass.	24-Pounder . . .	5·66	10·0	56·6	9·68	54·8	13 2	8·5	5·66	4·25
	12 Ditto.	4·52	10·0	45·2	9·8	44·3	6 2	6·8	4·52	3·4
	$5\frac{1}{2}$-Inch	5·62	5·75	32·3	5·25	29·5	10	7·02	4·215	4·215
	$4\frac{2}{5}$ Ditto.	4·52	5·0	22·6	4·62	20·9	2 2	4·8	2·26	2·26
Iron.	10-Inch	10·	6·0	60·0	5·88	58·75	40	11·25	10·0	7·5
	8 Ditto	8·0	6·0	48·0	5·85	46·8	20	9·5	8·0	6·0

HURDLES.

Small hurdles, 3 feet high, and 2 feet broad, are very useful at sieges, especially when the materials for the trenches are to be brought from a distance. Three of these hurdles, placed in the form of a prism, and connected at the edges, constitute a kind of triangular gabion.

The process and materials for making them, are precisely the same as for gabions, except that the pickets are planted in a right line instead of a circle.

These hurdles, or triangular gabions, when made of sufficient dimensions, are very useful in forming the teeth of the cremaillères in the saliant angles of field-works. They should, for this purpose, be formed in threes, by having some of the stuff of the centre hurdle worked into the outer ones, and of these last, into the centre one; by which means, a species of joints will be formed, allowing of their being packed into one-twentieth of the space required for a common gabion of the same capacity.

ISINGLASS

Is a gelatinous substance, prepared from certain parts of the entrails of a particular species of fish. The best isinglass is derived from the sturgeon, and is prepared almost exclusively in Russia. It should be free from taste and smell, and entirely soluble in warm water, which, however, is seldom the case, in consequence of the presence of some albuminous parts.

When the jelly of isinglass is concentrated by eva-

poration, and carefully dried, it forms a choice kind of glue, and is employed in fire-work compositions, to give them consistency.

LEVELLING

Is the art of finding how much higher or lower any given point on the surface of the earth is, than another point on the same surface; or, in other words, the difference in their distances from the centre of the earth.

The apparent level is a straight line tangential to the surface of the earth, or true level. Every point of the apparent level, except the point of contact, is higher than the true level.

Table shewing the Difference between the True and Apparent Level at different Distances.

Distance	Difference of Level.	Distance	Difference of Level.	Distance	Difference of Level.
Yards.	Inches.	Yards.	Inches.	Yards.	Inches.
100	0·026	1200	3·701	10560	287·0
200	0·103	1300	4·344	12420	390·0
300	0·231	1400	5·038	14080	510·0
400	0·441	1500	5·784	15840	645·0
500	0·643	1600	6·58	17600	796·0
600	0·925	1700	7·425	19360	963·0
700	1·26	1760	8·0	21120	1142·0
800	1·645	3520	30·0	22880	1346·0
900	2·081	5280	72·0	24640	1561·0
1000	2·570	7040	127·0	26400	1800·0
1100	3·11	8800	199·0	28160	2100·0

The foregoing Table will answer several useful purposes.

1. *To find the Height of the Apparent Level above the True, at any Distance.*

If the given distance be contained in the table, the correction of level will be found in the same line with it; but if the exact distance be not found in the table, then multiply the square of the distance, in yards, by 2·57, and divide by 1,000,000, or, which is the same thing, cut off six places on the right for decimals, and the remaining figures will be the correction in inches. Otherwise, multiply the square of the distance in miles by 66 feet, 4 inches, and divide by 100.

Example. An object appearing in the horizon at the distance of 440 yards, required the difference between its true and apparent level?

Here, $(440)^2 \times 2{\cdot}57 = 49755{\cdot}2$, consequently the correction of level will be ·497552 of an inch, or ½ of an inch nearly.

2. *To find the Extent of the visible Horizon, or how far can be seen from a given Height.*

The height of the observer's eye above the horizon being known, the extent of his visible horizon will be found in the opposite column of distances; but if the given height be not found in the table, multiply that height, in inches, by 1,000,000, divide the product

by 2·57, and take the square root of the quotient for the extent of the horizon.

Example. The height of an observer's eye above the horizon being 50 feet or 600 inches, required the distance to which he can distinguish objects?

$$\text{Here, } \sqrt{\frac{600 \times 1{,}000{,}000}{2{\cdot}57}} = \sqrt{233{,}463{,}035} \text{ inches,}$$

or 15,279 yards, or $8\frac{2}{3}$ miles nearly.

3. *To find the Distance of an Object when it first comes in Sight, its Height being known.*

The distance of any object will be the extent of the visible horizon of the observer, added to that of the visible horizon of the point he observes. It is only necessary in this case for the observer to know the height of that part of the object which is kept from his view, by the curvilinear figure of the earth. Also, knowing the distance of an object, its height may be found in the same manner.

If the height, or distance, exceeds the limits in the table, then, First:—if the distance be given, divide it by 2, 3, or 4, &c. till the given distance comes within the limits in the table. Then, take out the height answering to the quotient, and multiply it by the square of the divisor for the height required. Second:—when the

height is given, divide it by one of these square numbers, 4, 9, 16, 25, &c. till the quotient comes within the limits of the table, and then multiply that quotient by the square root of the divisor, the product will be the required distance.

LEVERS.

Weight and Dimensions of Levers.

Iron shod, 4 feet long. Weight of 5, 36 lbs.
Common, 6 feet, 6 inches long. ditto, 54 lbs.

See the word MECHANICS.

LEAGUE.

A measure of length, varying in the number of geometrical paces it contains, according to the usages of different countries. A league at sea, where it is chiefly used by us, contains 3000 geometrical paces, or 3 English miles.

The French league sometimes contains the same measure; but in some parts of France it consists of 3500 paces. The mean or common league consists of 2400 paces, and the little league of 2000.

The Spanish leagues are of greater extent than the French, 17 Spanish leagues making a degree, or 20 French leagues, or 69½ English statute miles.

The German and Dutch leagues contain each 4 geographical miles.

MAGAZINES.

In fortified places, powder magazines should be placed in isolated situations, and distributed in the several parts of the works, that the danger always attending them may, as far as possible, be provided against, when the side of attack is determined on, by removing all the powder not absolutely required for the daily service of the batteries to points as distant as possible from the directions of the enemy's fire.

According to Vauban's plan, they are commonly made sixty feet long, and twenty-five feet wide in the clear. The foundations of the longest sides are nine or ten feet thick, and six feet or more in depth, according to the nature of the ground. The side walls raised upon these foundations are eight or nine feet thick; and, if it be not intended that there should be an upper story, eight feet will be a sufficient height above the foundation. By this means the flooring may be raised so far above the ground as to be secure from damp, and there will remain six feet from the floor to the spring of the arch.

The arch is formed of layers of bricks, disposed one over the other, and it ought to be at least three feet thick in the thinnest part, that it may be bomb-proof. The exterior surface is formed by two planes touching the curvé on the hances, and meeting in a ridge over the vertex of the arch, so as to make the thickness in that part equal to eight feet.

The foundations of the gable ends, in which are the doors and windows, are five feet thick, and of the same depth as those of the sides. The walls raised upon these foundations are four feet thick throughout their whole height.

The long sides, from the tops of which the arches spring, are strengthened, at every twelve feet, by rectangular counterforts, six feet deep, and four feet thick.

The ventilators, placed one in the centre of each space between the counterforts, are constructed with a die, or traverse one foot, six inches square across them, and are closed on the outside by plates of copper, through which a number of air-holes, about half an inch in diameter, are perforated.

The entrances and windows, one of each of which should, if possible, be towards the south, are secured by double doors, one opening inwards, and the other outwards. The outward one is covered with sheet copper, as is every part of the wood-work which is, from its situation, exposed to the weather. Lastly, at the distance of twelve feet from the magazine, a wall fourteen inches thick, and ten feet high, is, as a further security, raised round it.

A magazine of the above dimensions will contain about 94,800 lbs. of powder, in piles of three barrels each.

At sieges, temporary or expense magazines are

usually constructed at about twenty or twenty-five fathoms in rear of the batteries. They ought to be well covered from the fire of the place, and, if possible, situated in rear of one of the merlons.

Too much attention cannot be paid to the construction of these temporary magazines, and to the communications from them to the batteries. When they cannot be sunk in the ground, they must be well secured by means of sand-bags, gabions, &c.

MARCHING.

The *Quick Step* or *March* is at the rate of 108 paces per minute, each pace being 30 inches, making 270 feet in a minute.

Wheeling-Step, 120 per minute, of 30 inches each, making 300 feet per minute.

Double-March, 150 steps per minute, each of 36 inches, making 450 feet in a minute.

Side, or *Closing-Step*, 10 inches each, 75 per minute.

Slow-Step, or *March*, 75 paces per minute, each of 30 inches, making 178 feet, 6 inches, in a minute.

SIR H. TORRENS.

RATE OF MARCHING.

Cavalry.—The rate of marching of a regiment of cavalry for six hours is calculated at 17 miles; but in cases of necessity, it may be extended to 21, or even 28 miles in that time.

D'ANTONI.

A small detachment may gallop for 5 minutes without halting, if the horses be in good condition. Thus, calculating 500 paces to each minute, 2,500 paces may be performed in 5 minutes.

When the above distance is to be exceeded, it is necessary to move at a trot, which, however, cannot be continued above half an hour. A party of cavalry may perform 300 paces in one minute, 6,000 in 25, and 9,000 in 30 minutes, at a trot. Thus a common German mile (4 English Miles) may be performed in half, or at the utmost, in three-quarters of an hour, provided the party is to halt immediately afterwards.

When a greater distance is to be performed, it is impossible, even when the roads are good, to march more than 6 German (24 English) miles in 12 hours, without fatigueing the horses too much; and when obliged to march 20 German (80 English) miles, or further, not more than 8 German (32 English) miles, can be calculated upon in 12 hours: all the horses, however, will not be equal to this.

SCHARNHORST.

The mean of the above, for ordinary marches, is equal to 17 English miles in 6 hours, or nearly 3 miles in one hour.

Infantry.—In common marches that continue about 6 hours, a soldier moves with a free and natural step, about two miles and one third in an hour; a regiment,

therefore, when the roads are good, marches 14 miles in 6 hours.

D'ANTONI.

A small party may march for a short time, that is, for an hour or an hour and a half, at the rate of 100 paces in a minute; and can, consequently, perform 9,000 paces, nearly a German mile, (or 4 English miles) in an hour and a half; but it is not possible to march more than five times that distance in 10 hours.

Large detachments cannot move even at the above rate, and it is frequently impossible for an army, in an intersected country, to perform more than 2 common German (8 English) miles in a day. The rate of march of an army, is generally from 2½ to 3 German (10 to 12 English) miles in a day; in particular cases, however, 4 or even 5 German (16 or 20 English) miles may be performed in a day, when there are no defiles to pass, and when the army moves in several columns.

SCHARNHORST.

The mean of the above, for ordinary marches, is equal to about 15 English miles in 6 hours, or about 2½ miles in one hour.

Artillery.—When the horses start fresh, and rest immediately after finishing the work, they may, if the roads be not bad, perform 2 miles in half an hour.

4 Miles	in $1\frac{1}{2}$	Hours.	
8 ditto	4	ditto.	And,
16 ditto	10	ditto.	

In the camp near Hanover, in 1791, the Horse Artillery performed 350 paces in a minute, 3,500 in $9\frac{1}{2}$ minutes, 6,000 in 22 minutes, and 12,000 in an hour.

SCHARNHORST.

MATCH.

There are two descriptions of match; viz. Quick and Slow.

QUICK-MATCH.

Composition.—Cotton wick, 1 pound 12 ounces; pulverized saltpetre, 1 pound 8 ounces; mealed powder, 10 pounds; spirits of wine, 2 quarts; and rain water, 3 pints.

The following proportion of ingredients is calculated to prepare 53 pounds of match.

Cotton wick, 7 pounds; saltpetre, 6 pounds; mealed powder, 40 pounds; spirits of wine, 2 gallons; and rain water, 6 quarts.

SLOW-MATCH.

The slow-match used in this country is usually prepared from a kind of slightly twisted hemp soaked

in a strong lye. It is furnished by contract:—a yard burns about eight hours.

During the Siege of Gibraltar, slow-match was made there in the following manner; eight ounces of saltpetre were put into a gallon of water, and just made to boil, over a slow fire; sheets of strong blue paper were then saturated with the liquor, and hung up to dry. When dry, each sheet was divided into two parts, which were rolled up tight, and the outward edges pasted down to prevent their opening.

Each half-sheet thus prepared will burn about three hours.

MATERIALS (Strength of).

When a beam or bar is acted on by any force, the power which it exerts to resist that force is called its strength, which may be distinguished into absolute and relative, according to the manner in which the force affects the cohesion of the particles composing the body. In order to investigate the strength of a body, it is necessary to imagine it to consist of a number of contiguous fibres, arranged in directions parallel to its length.

If an effort be made to tear asunder the fibres of any material, in the direction of their length, that strain is directly opposed to the cohesive power by which the particles are held together; therefore, the power of a body to resist this kind of strain may be

considered as its absolute strength, and this will evidently be proportional to the number of fibres, or to the area of a transverse section of the beam or bar.

From experiments performed by Mr. Barlow, of the Royal Military Academy, it appears that a rod of each of the following kinds of wood, one inch square, and of any length, will bear, suspended from it, the weights annexed to each material separately in the following table, the weight of the rod itself not being included.

	lbs.		lbs.
Box-wood	20,000	Beach	11,500
Ash	17,000	Oak	10,000
Teak	15,000	Pear-tree	9,800
Fir	12,000	Mahogany	8,000

Malleable Iron.... 60,480; from the experiments of Captain Brown and Mr. Telford.

Rope (1 inch in circumference), 1,000lbs.; from the experiments of Muschenbrock.

Mr. Barlow also finds that the lateral adhesion of the fibres of fir is equivalent to about 600 lbs. on every square inch, when drawn asunder in the direction of their length. And he considers that the weights in the above table are such as will tear the bodies asunder in a minute or two; two-thirds of them will impair the strength, if suspended a considerable time, and one-half is the most that ought to be left suspended from them permanently.

When any body supports a weight placed upon it, the particles composing it are separated laterally; and the strength of the body in this respect consists in the cohesion of these particles, and their friction between those above and below them. This strength is found to be in a higher ratio than the area of a transverse section of the material, but the precise value is yet unknown. The experiments of M. Gauthey and others on the capability of different materials to support weights, afford the following results:—

A pillar of hard stone, its section being one foot square, bore		871,000 lbs.
Ditto	ditto	664,000
Ditto	ditto	460,000
Ditto, of soft stone,	ditto	249,000
Ditto, of brick	ditto	320,000
Ditto, of chalk	ditto	9,000
Ditto, of oak, its section being one inch square		9,000
Ditto, of fir	ditto	18,000

When an elastic body, considered as an assemblage of parallel fibres, is pressed in the direction of its length, it is found, both from theory and practice, to be susceptible of inflexion; and Mr. Barlow has given the following formula for determining the weight under which a rectangular column of timber of given

elasticity will bend when placed in a vertical position, viz.—

$$W = \frac{0\cdot2056 E \,.\, a \,.\, d^3}{l^2}.$$

Where W =, the weight required.

E =, an expression for the elasticity of a beam of the given kind of wood, and the value of which must be taken from the following table.

a =, the thickness of the beam in the direction of the longer side of the section.

d =, the thickness in the direction of the shortest side.

l =, the length of the column.

The following is Mr. Barlow's table of the value of E for different kinds of wood.

Teak...........	9,657,802	Elm	2,799,347
English oak....	4,650,465	Pitch pine......	4,900,466
Canadian ditto	8,595,864	Red ditto	7,359,700
Dantzic ditto..	4,765,750	Riga fir	4,638,685
Adriatic ditto	3,885,700	New Forest do.	3,179,352
Ash	6,580,750	NewEngland do.	5,967,400
Beech	5,417,266	Larch..........	3,619,556

Norway spar, 5,832,000.

When the particles are forced from their places by a pressure in a direction transverse to the length of the

body, the strength seems to depend upon a lateral cohesion and friction of the particles on each side of the plane of fracture. And, from such experiments as have been made, it appears that the strength by which a body resists this force of detrusion is about double of its absolute strength; probably because the separation is made at two surfaces.

When a beam is fixed at one end to a wall, and none of the fibres are subject to compression, the effect of a weight at the other end will be to cause the beam to separate from the wall, as if it turned upon a joint close to the wall at the lower surface of the beam. In this case, each fibre is strained by the weight with a force which diminishes as the distance of the fibre from the lower surface of the beam increases; therefore, the cohesive power exerted by the particles of any fibre may be considered as proportional to the distance of the fibre from the bottom; and that cohesive force acts at the extremity of a lever, of which the length is equal to such distance; consequently, the strength of any fibre is proportional to the square of its distance from the bottom of the beam. And if a longitudinal section of each of two beams be taken in a vertical plane, the strength of a fibre similarly situated in each, will be proportional to the square of the depth of the section. Therefore the strength of the whole of each section will also be proportional to the square of the depth. And because the strength of a beam is

evidently also proportional to its breadth, the strength of the whole beam will be proportional to the term $b \cdot d^2$. Where b expresses the breadth, and d the depth of a beam; and its absolute resistance may be expressed by $b \cdot d^2 \cdot S$, which is the formula given by Mr. Barlow. If b and d are expressed in inches, the term S, which is a constant quantity, expresses the resistance of a rod one inch square, and may be determined by experiment.

The strain produced by the weight will be expressed by the product of that weight into the length of the lever, at the extremity of which it acts, viz.—the length of the beam itself, neglecting the effect arising from its deflection; which, in architectural works, is inconsiderable. And when the strength is just equal to the strain, these two expressions should be equal to each other. Therefore, to find the weight which a beam, attached at one end to a wall, will bear without breaking, we have the equation $l \cdot W = b \cdot d^2 \cdot S$, where l, b, d, are to be expressed in inches, W and S in pounds, and W, the only unknown quantity, may be found.

Mr. Barlow finds the value of S to be a constant quantity for each kind of wood; and he determines its value from the above equation, when W is known from the experiments.

The following is Mr. Barlow's table of the value of S:—

Teak	2462	Dantzic oak	1457
English oak..........	1426	Adriatic ditto	1583
Canadian ditto......	1766	Ash	2026
Beech	1556	Riga fir	1079
Elm	1013	Mar forest ditto	1223
Pitch pine	1632	Larch	990
Red ditto...........	1341	Norway spar	1474
New England fir....	1102	Cast iron	7510

When a beam of the same breadth and depth, and double the length of the former, is supported by a prop in the middle, and strained by a weight at each end, equal to that which may be supposed to be applied to the former beam, the extension of the fibres over the prop will be the same in this case as at the place of attachment in the former; consequently the equation of equilibrium will be the same as before, only substituting $\frac{1}{2}\, l$ for l, and $\frac{1}{2}\, W$ for W; because l and W now represent quantities double of those which they represented before. Therefore, the formula becomes $\frac{1}{4}l \,.\, W = b \,.\, d^2 .\, S$; disregarding the deflection.

When the beam is supported loosely on a prop at each end, and loaded with a weight in the middle, the reaction of the props may be considered equal to the action of the weights at the extremities of the beam in the former case, and the action of the weight in the present case, equal to the reaction of the prop in the middle. Admitting this supposition, the equation of stability will be the same as before; but, on account

of the obliquity of the reaction of the props, caused by the deflection, and the slipping of the beam between them, it is shewn by Mr. Barlow that the strain in the latter case is to the strain in the former, in the duplicate ratio of radius to the cosine of deflection. When, however, the deflection is small, it may be neglected, and the above equation employed.

Mr. Barlow also shows that, since it requires four times as much weight to produce a certain deflection in a beam supported at each end, as is required to produce the same deflection in a beam of half its length, when supported at one end only, it will follow that, when a beam is firmly attached to a prop at each end, two-thirds of the whole weight is employed in producing the central deflection, and one-sixth, in producing that at each end. Consequently the weight necessary to produce fracture at the middle of the beam, in this case, is to that which is necessary in the former case, as 3 to 2. And the equation of stability becomes $\frac{1}{6} l \,.\, W = b \,.\, d^2 .\, S$; neglecting the deflection.

When the weight is not in the middle, let P be the product of the unequal distances of the weight from the two ends. Then the equation for a beam placed loosely on two props will be $\frac{P \,.\, W}{l} = b \,.\, d^2 .\, S$; and, for a beam fixed at each extremity, $\frac{2}{3} \frac{P \,.\, W}{l} = b \,.\, d^2 .\, S.$

When the weight is equally diffused over the beam, the expression for the strain is equal to one half of that

which has been found for an equal weight applied in the middle of the beam.

When a beam is subject to a transverse strain, part of the fibres are subject to extension, and the remainder to compression; and, from experiment, Mr. Barlow fixes the position of the neutral axis, in fir timber, at three-eighths of the depth of the beam; reckoned from the place where the fracture commences.

From Mr. Banks' experiments on the transverse strength of materials, we have the following results. Each material was in the form of a bar, the section of which was one inch square; it rested on a prop at each extremity, and the distance between the props was one foot.

The weakest bar of heart of oak bore without breaking	660 lbs.
The strongest ditto	974
The weakest bar of deal	460
The strongest ditto	690
A bar of white marble	500
The weakest bar of cast iron	2190

When beams are compressed in the direction of their length, they are more easily broken by a transverse strain, than when not subject to such compression.

The most advantageous form of a beam to resist a transverse pressure, is that in which the section is a

parallelogram, the broadest side being parallel to the direction in which the weight acts.

A hollow cylinder is stronger than a solid one of equal length, and containing the same quantity of material.

The force by which a cylinder of any material resists the strain of torsion may be compared with that by which it resists the force of detrusion, at one surface; for if the material be supposed to be divided in a section perpendicular to its axis, the particles are separated from those contiguous to them by sliding over them laterally.

Now suppose the section to be formed of an infinite number of circumferences concentric with the axis of torsion, which is the axis of the cylinder, the cohesive power by which each particle in any one circumference is held to a lateral particle, is proportional to the semi-diameter of the circumference which is the length of the lever at the extremity of which the cohesive power acts; and the power by which all the particles in each circumference are held is proportional to the number of particles in it; that is to the same semi-diameter. Therefore, the resistance of all the particles in one circumference to the power of torsion, is proportional to the square of the radius of that circumference, and the sum of all the resistances in the cylinder will be expressed by the sum of the squares of an infinite series of the terms 1, 2, 3, &c. expressing the distances of all the circumferences from the centre, the

last term being the radius of the cylinder. This sum is equal to $\frac{1}{3}$ (Rad.)^3. While, if the distance of all the particles from the centre were equal to that radius, the sum of as many terms, each equal to (Rad.)^2 would be (Rad.)^3.

But in the last case the strength of the section is equal to that by which it resists the strain of detrusion at one surface; which is supposed equal to the absolute strength of the material. Therefore, the resistance of any body against the power of torsion is equal to one-third of its absolute strength, or one-third of that force which would break the fibres of a body by a direct pull, would break them by twisting.

MEAN.

This term, in general, denotes the middle between two extremes:—thus, we say, the mean distance, mean proportion, &c.

The *arithmetical mean* is half the sum of the two extremes, as 4 is the arithmetical mean between 2 and 6; for $(2+6) \div 2 = 4$.

The *geometrical mean* is the square root of the product of the two extremes:—thus, $\sqrt{(1 \times 9)} = \sqrt{9} = 3$.

To find Two Mean Proportionals between Two Extremes.

Multiply each extreme by the square of the other, and the cube roots of these two products will be the mean proportionals required.

Dimensions of Cylindrical Measures, containing the Established Service Charges of Coarse or Fine Grained Powder.

Nature of Ordnance.		Charge of Powder.	Proportion of Charge of Powder to the Shot.	Coarse Grained.		Fine Grained.	
				Axis and Diameter.	Weight of Distilled Water.	Axis and Diameter.	Weight of Distilled Water.
		lbs. ozs. drs.		Inches.	lbs. ozs. drs.	Inches.	lbs. ozs. drs.
Guns. Full Charges.	32-Pounder.	10 10 10·624	$\frac{1}{3}$	7·705	13 1 2·406	7·824	13 9 10·953
	24 ditto...	8	$\frac{1}{3}$	7·001	9 13 13·781	7·109	10 3 4·25
	18 ditto...	6	$\frac{1}{3}$	6·361	7 5 10·344	6·459	7 10 7·219
	12 ditto...	4	$\frac{1}{3}$	5·556	4 14 6·906	5·642	5 1 10·125
	9 ditto...	3	$\frac{1}{3}$	5·048	3 10 13·156	5·126	3 13 13·390
	6 ditto...	2	$\frac{1}{3}$	4·41	2 7 3·328	4·478	2 8 13·063
	4 ditto...	1 5 5·312	$\frac{1}{3}$	3·852	1 10 2·188	3·912	1 11 3·312
	3 ditto...	1	$\frac{1}{3}$	3·5	1 3 9·376	3·555	1 4 6·5
	2 ditto...	10 10·624	$\frac{1}{3}$	3·058	13 1·125	3·105	13 9·656
	1 ditto...	5 5·312	$\frac{1}{3}$	2·427	6 8·188	2·464	6 12·188
Guns. Reduced Charges.	32-Pounder.	8	$\frac{1}{4}$	7·001	9 13 13·781	7·109	10 3 4·25
	24 ditto...	6	$\frac{1}{4}$	6·361	7 5 10·344	6·459	7 10 7·219
	18 ditto...	4 8	$\frac{1}{4}$	5·779	5 8 3·797	5·868	5 11 13·344
	12 ditto...	3	$\frac{1}{4}$	5·048	3 10 13·156	5·126	3 13 13·406
	9 ditto...	2 4	$\frac{1}{4}$	4·587	2 12 1·875	4·685	2 13 14·656
	6 ditto...	1 8	$\frac{1}{4}$	4·007	1 13 6·5	4·069	1 14 9·875
	4 ditto...	1	$\frac{1}{4}$	3·5	1 3 9·376	3·555	1 4 6·312
	3 ditto...	12	$\frac{1}{4}$	3·18	14 11·312	3·229	15 7·344
	2 ditto...	8	$\frac{1}{4}$	2·778	9 12·752	2·821	10 3·25
	1 ditto...	4	$\frac{1}{4}$	2·205	4 14·376	2·239	5 1·625
Carronades.	68-Pounder.....	5 10 10·624	$\frac{1}{12}$	6·241	6 15 4·906	6·337	7 3 10·312
	42 ditto.......	3 8	$\frac{1}{12}$	5·315	4 4 9·969	5·396	4 7 5·844
	32 ditto.......	2 10 10·624	$\frac{1}{12}$	4·854	3 4 4·156	4·929	3 6 6·406
	24 ditto.......	2	$\frac{1}{12}$	4·41	2 7 3·390	4·478	2 8 13·063
	18 ditto.......	1 8	$\frac{1}{12}$	4·007	1 13 6·5	4·069	1 14 9·75
	12 ditto.......	1	$\frac{1}{12}$	3·5	1 3 9·376	3·555	1 4 6·5

The above table of powder measures applies more particularly to the Navy than to the Land Service, and was computed by Mr. Hookham, the Deputy Inspector of the Proof Department, to whose kindness I am indebted for it.

The following rules, though they can only be regarded as approximations, will be found of great practical utility.

To find how much Powder will fill a given Cylinder.

Multiply the square of the diameter by the length of the axis; then divide by 38·2 for the powder in pounds.

Example. The diameter of a cylinder being 10, and the length of its axis 20 inches; how much powder will it contain?

Here, $\frac{10 \times 10 \times 20}{38{\cdot}2} = 52$ lbs. 5oz., nearly.

To find what Length of a Cylinder will be filled by a given Weight of Powder.

Multiply the weight, in pounds, by 38·2, and divide the product by the square of the diameter, in inches, for the length.

Example. The bore of a 32-pounder being 6·41 inches, what length of it will be filled by 12 lbs. of powder?

Here, $\frac{12 \times 38{\cdot}2}{(6{\cdot}41)^2} = \frac{458{\cdot}4}{41{\cdot}0881} = 11{\cdot}107$ inches, nearly.

To find the Size of a Cubical Box to contain a given Weight of Powder.

Multiply the weight, in pounds, by 30, and the cube root of the product will be the side of the box, in inches.

Example. Required the dimensions of a cubical box, to contain 50 lbs. of powder?

Here, $\sqrt[3]{(50 \times 30)} = \sqrt[3]{1500} = 11{\cdot}44$ inches.

To find the Length of the Side of a Square Box, the Depth being given, to contain a given Weight of Powder.

Divide the given weight, in pounds, by the product of 55, and the given depth; and the square root of the quotient will be the length.

Example. The depth of a square box being 1 foot, what must be the length of its side that it may contain 380lbs. of powder?

Here $\sqrt{\frac{380}{55}} = \sqrt{6{\cdot}9} = 2{\cdot}6267$ feet, or $31{\cdot}5$ inches.

To find how much Powder will fill a Rectangular Box.

Find the content of the box, in inches, by multiplying the length, depth, and breadth together. Then divide by 30 for the powder, in pounds.

Example. The length, breadth, and depth of a box being 15, 12, and 10 inches respectively; what quantity of powder will it hold?

Here $\frac{15 \times 12 \times 10}{30} = \frac{1800}{30} = 60$ lbs.

See also the word WEIGHTS.

MECHANICS.

Mechanics is the science which treats of the actions and effects of moving bodies upon one another, or it is the science of equilibrium and of motion.

The mechanical powers are those simple machines by means of which any force may keep in equilibrio one which is greater than itself; and one or more of these enters into the composition of every compound machine.

The mechanical principle by which a moving force may counterbalance a resistance greater than itself is, that part of the resisting body is supported by the machine, so that only the remaining part is opposed to the action of the moving force. The ratio between the moving and resisting forces is capable of being determined by the general theory of forces.

There are seven mechanical powers, viz.—*The Lever, the Wheel and Axle, the Pulley, the Inclined Plane, the Wedge, the Screw*, and *the Funicular Machine.*

THE LEVER.

There are four kinds of levers. The first is that in which the rod is supported, in some part of its length, on a fulcrum, and the moving and resisting powers are at opposite ends of the rod;—as in the case of elevating a gun by means of a hand-spike,—where the resistance to be overcome is the gun, the cheek of the carriage the fulcrum, and the man the moving power. The second, is that in which one end of the rod rests on the fulcrum, the moving power is at the other end, and the resistance is in some part of the length of the rod. This power is illustrated in the action of running up a gun after recoil,—where the platform represents the ful-

crum, the gun and carriage the resistance, and the man the moving power. The third, is that in which one end rests on the fulcrum, the resistance is at the other end, and the moving power in some part of the length. Which may be illustrated in the action of raising scaling ladders against the ramparts of a place; for here the ground is the fulcrum, the weight of the ladder the resistance, and the detachment raising it the power. The fourth is like the first, only the rod is bent for convenience, and the fulcrum is at the angular point. The moving and resisting powers are supposed to act in all cases perpendicularly to the lengths of the arms of the levers to which they are respectively applied. The levers, also, are considered as without weight, or their arms to be in equilibrio before the weights are applied.

In the first lever, by the theory of parallel forces, when an equilibrium subsists, the power, is to the resistance, as the distance of the point of application of the resistance from the fulcrum, is to the distance of that of the power from the fulcrum; or the power multiplied into its distance from the fulcrum is equal to the product of the resistance into its distance from the same point. The same rule holds good for the other three kinds of levers, because, in all the four cases, the power, resistance, and pressure on the fulcrum, are three forces expressed by the same terms, but reciprocally interchanging values with each other, and

of which one is always equal and acts in a direction opposite to those of the other two.

When the directions of the power and resistance are not perpendicular to the arms of the lever, lines must be drawn from the fulcrum perpendicularly upon the lines of direction of the forces; and then the former proposition will hold good, if the distances of the forces from the fulcrum are measured on these perpendiculars.

If the arms are not in equilibrio when the forces are applied, multiply the weight of each arm into the distance of its centre of gravity from the fulcrum, and add each product to the like side of the former equation. The sum will form an equation from which the moving power may be found.

If a number of levers be combined together, the power at the end of the first arm is to the resistance at the end of the last, as the product of all the short arms is to the product of all the long arms.

THE WHEEL AND AXLE.

This power forms a machine analogous to a lever of the first kind, the fulcrum being at the centre of motion. Therefore, in the case of equilibrium, the power, is to the resistance, as the radius of the axle, to the radius of the wheel; or, as the circumference of the axle, is to the circumference of the wheel.

If two or more wheels and axles are combined together by strings, or by teeth cut in their circumferences,

the power at the circumference of the first wheel, is to the resistance at the circumference of the last axle, as the product of the radii of all the axles, is to the product of the radii of all the wheels; or, as the continued product of the number of teeth in each axle, to the continued product of the number of teeth in each wheel, supposing every wheel and axle to have teeth.

THE PULLEY.

A moveable pulley is analogous to a lever of the second kind, the fulcrum being at the fixed extremity of the rope, the power applied at the other extremity, and the resistance at the centre of the pulley. Then, when the two directions of the rope are both parallel to the same diameter of the pulley, the power, is to the resistance, as the radius of the pulley, is to its diameter, or as 1 to 2. And when several pulleys are combined in two blocks, the same ratio is repeated as often as there are pulleys in the moveable block; therefore, if n represent the number of pulleys in the latter, the power, is to the resistance, as 1 to $2n$, so that if $n = 3$, we have the power to the resistance as 1 to 6.

If a number of strings be made fast to immoveable points at one end, and each be made to pass under a moveable pulley, and the other end be attached to the block of the next pulley, and so on; then if a resistance be applied to the first block, and a power at the extremity of the last rope, the system will be analogous to a compound lever, of the second kind. Therefore,

if n be the number of moveable pulleys, the ratio of the power to the resistance will be as 1 to $2n$, so that if $n = 3$, we have the power to the resistance as 1 to 8.

THE INCLINED PLANE.

When a body is supported on an inclined plane, it is kept in equilibrio by three forces, viz.—the power of gravity, the sustaining power, and the re-action of the plane; which all concurring in the body, the ratios between them are, by the composition of forces, proportional to the three sides of a triangle coinciding with, or parallel to the directions in which the forces act. When the sustaining power acts in a direction parallel to the length, or parallel to the base of the plane, the triangle of forces is similar to that formed by the hypothenuse, base, and perpendicular of the inclined plane; in the first case, the sustaining power is to the weight of the body, as the height of the plane is to the length of the hypothenuse; and, in the second case, the sustaining power is to the weight as the height of the plane is to the length of the base.

THE WEDGE.

This is analogous to an inclined plane, for on entering the material, the divided part seems to move along the slant side, as a body moves up an inclined plane. Therefore, if the impelling force be perpendicular to the head of the wedge, that force, together with the resistance and the re-action of the wedge, form three

forces in equilibrio, which will be proportional to the sides of a triangle, drawn parallel to, or coinciding with the directions in which the forces act. Consequently when the divided part turns on a joint at the angle of the wedge, the impelling power, is to the resistance, as half the breadth of the head of the wedge, is to its slant length. And when the divided part moves in a direction parallel to the head of the wedge, the impelling power, is to the resistance, as half the breadth of the head of the wedge, is to its perpendicular length.

THE SCREW.

When a screw, by turning on its axis, enters any material, the parts contiguous to the sides of the threads, seem to move along the sides, just as a body moves up an inclined plane. Therefore, in the case of an equilibrium, the moving power acting at the circumference of the screw, is to the resistance in the direction of the axis, as the distance between every two threads, measured in a direction parallel to the axis, is to the circumference of the screw. But if a wheel or lever be fixed to the axis, as is the case with the elevating screw of a gun, and the moving power be applied at the circumference of the one, or at the extremity of the other, the ratio of the circumference of the screw to the circumference of the wheel, must be compounded with that of the distance of the threads to the circumference of the screw, and the

result will be, that the power is to the resistance, as the distance of the threads, to the circumference of the wheel.

THE FUNICULAR MACHINE.

If a string be made to pass over two fixed pulleys, and a weight be applied to the string, in any position between the pulleys, and another weight at each of the two extremities beyond the pulleys; the whole is called the Funicular Machine, and the ratio of the three weights can be found by forming a triangle with lines drawn parallel to, or coincident with the directions in which they pull from the points of application of the weight between the pulleys; therefore any one of them, being unknown, can be determined.

MILE.

The length of the *Geographical* mile varies in different countries. The *Geometrical* mile contains 1000 Geometrical paces, or *mille passus*, from whence miles are denominated.

We shall here give an itinary table of the length of the miles in use among the principal nations of Europe, in English yards.

Arabia	2148
Bohemia	13137
Brabant	6082
Burgundy	6183
Denmark	8244

England	1760
Flanders	6869
Germany, geographical miles	8101
long ditto	10126
short ditto	6859
Hamburgh	8244
Hanover	11559
Hesse	10547
Holland	6395
Hungary	9113
Ireland	3038
Italy	2025
Oldenburg	10820
Poland, long mile	8101
short ditto	6075
Prussia	8468
Saxony	9905
Scotland	1984
Silesia	7083
Swabia	10126
Sweden	11700
Switzerland	9153
Westphalia	12151

MINES.

A military mine is a small cavern formed under the terreplein, or ramparts, or behind the revêtements of such works as it is intended to destroy, by means of the explosive force of a given charge of gunpowder.

The subterranean passage which leads from the shaft to the mine is called the gallery, and the place where the powder is lodged, the chamber, of the mine. Also, the shortest line that can be drawn from the centre of the chamber, to the surface of the ground, is called the line of least resistance.

The excavation formed by the explosion is called the funnel or crater, and takes the name of a one, two, or three lined, &c. crater, according as its diameter is equal to one, two, or three times the length of the line of least resistance.

To Compute the Charge for any given Mine.

Cube the line of least resistance, expressed in feet, and take one-tenth of the result for the charge in pounds.

Thus, supposing the length of the line of least resistance of a mine to be 20 feet, required the charge?

Here, $\frac{20 \times 20 \times 20}{10} = \frac{8000}{10} = 800$ lbs. The charge required for the production of an ordinary crater.

The charges found by means of this rule being adapted to only one description of soil; viz.—common earth, they must be augmented or diminished, according to the following table of Vaubans, by one, four, five, seven, or nine elevenths of the charge found, in proportion to the nature of soils, &c.

Table of the Quantity of Powder required to raise a Cubic Fathom, according to the Soil, &c.

1	Light earth, mixed with sand	11 lbs.
2	Common earth	12
3	Strong sand	15
4	Clay or fat earth	16
5	Old and good masonry	18
6	Rock	20

PROCESS AND MODE OF PROCEEDING IN THE CONSTRUCTION OF A MINE.

The first step in the construction of a mine, whether for attack or defence, is to sink a shaft to the required depth, having two of its sides parallel to the intended direction of the gallery. These shafts should be sunk at the places underneath which it is intended two galleries should cross each other, or over the centre of the length of a gallery; and they should never be further apart than from 30 to 50 fathoms; for it is found, that the air is not fit for respiration in the larger galleries at a greater distance from the shaft than 25 fathoms; at 20 fathoms in those of medium dimensions, and at 15 fathoms in the smallest.

The rectangular frames used in sinking the shafts are commonly placed 4 feet asunder; and in the galleries only 3 feet.

A gallery intended to be lined with masonry must be 7 feet high, and 6 feet wide, in order that it may,

when finished, be 6 feet high, and 4 feet 6 inches wide. Temporary galleries are made only 4 feet 6 inches high, and from 2 feet 6 inches, to 3 feet wide.

The branches, at the ends of which the chambers are formed, are from 2 feet 6 inches, to 3 feet high, and from 2 feet, to 2 feet 3 inches wide.

The miners are divided into brigades of 4 each; and the rate of work for each brigade is 3 feet of the temporary gallery in 4 hours. The first brigade is relieved by a second, after having worked 4 hours, or laid one frame; and which second brigade is again relieved by the first, at the expiration of a second 4 hours In soil of a mean tenacity, a miner may be heard to the distance of from 14 to 15 fathoms under ground; and the noise made by fixing the frames may often be heard at a distance of from 20 to 25 fathoms.

In constructing mines of any description, the following observations may be of service:—

1. The best form for the chambers would be spherical; but from the difficulty of constructing such chambers, they are generally made of a cubical form, of one inch larger in each dimension than the box which contains the powder.

2. The chamber must not be made in the prolongation of the gallery, or branch of the mine, but at one side, and lower than the level of the branch, if the soil be dry, but higher if it be damp.

3. The auget is generally one inch square, interior dimensions, and the end of it must reach to the centre of the chamber; where one extremity of the saucisson or hose should be fastened, to prevent it being easily drawn out.

4. The stoppage, or tamping of a mine, is effected by placing boards before the aperture of the chamber, and planting struts from thence to the opposite wall of the branch; which is then filled up with earth or rubbish to a distance, estimated in a right line from the centre of the chamber, equal to once and a-half the line of least resistance.

5. When several mines are to be fired together, the saucissons are all brought to a point, called the focus, at an equal distance from each of them; or if this be not possible, the saucisson proceeding from the nearest mine must be disposed with bends, in order to make the whole development of its length equal to that of the saucisson from the farthest mine, allowing four inches for each rectangular return.

A glacis properly countermined, and every advantage taken of it to retard the besiegers in their approaches, may, according to Bousmard, with proper management, prolong a siege at least two months; and if the rest of the works are also countermined, and properly defended, they may add another month to the siege.

Every system of countermines must depend upon

the system of fortification to which it is to be applied; the general principle for their regulation is, that the galleries should occupy situations, from whence branches may be readily run out under the most probable points of the besiegers' batteries and approaches: The principal or *magistral* gallery runs all round the work, under the banquette of the covered-way, and across the places of arms; the entrances are usually formed in the faces of the counterscarpe, at the re-entering places of arms. Nearly parallel to the magistral gallery, and at from 25 to 30 fathoms distance a second is run, called the gallery of *envelope*. These two galleries are connected by galleries of *communication*, parallel to the gutters and ridges of the re-entering and saliant parts of the glacis. From the envelope gallery are run out, to about 15 or 20 fathoms, galleries in directions parallel to the capitals of the works, and at about 25 fathoms from each other. These latter are called *listeners*.

Shafts are sometimes sunk over the extremities of these listeners, and by connecting them, a second envelope is formed. Galleries are also formed behind the escarpe revêtements of the different works, at about the level of the bottom of the ditch; from whence branches may be run into, or under the foundations of the walls; and, if the ditches be dry, communications may be made from these to the magistral gallery; from which communication branches may be run out for chambers to annoy the besiegers in their

passage of the ditch. The entrances to the *escarpe-galleries* are by means of posterns, which descend from behind the interior slope of the rampart.

If a place be not countermined beforehand, a great deal may still be done, even after the investment, to prolong the siege by means of counter-mines. In this case, the first thing to be done, immediately after the investment of the place, is to sink a shaft in each of the places of arms in the covered-way, one in each of the branches of the covered-way, opposite that part of the bastion where the breach will most probably be made; and one in the flanked angle of each bastion. Those in the covered-way should be on the banquette, and sunk to about 18 inches, and those in the bastions, to about 12 feet below the bottom of the ditches. Thus prepared, the moment the side on which the attack is to be made, can be ascertained, galleries must be carried on from these shafts on the side attacked, along the capitals, in the form of trefoils; and advanced as far into the country as the time will admit of. Communication galleries may likewise be driven between these different works in the covered-way, and from them to the bastions, which will prevent the enemy from getting possession of the entrances. All these works may be carried on after the investment of the place, and be in sufficient forwardness by the time the enemy gains the third parallel.

MORTARS.

Weight and Dimensions of Land and Sea Service Mortars.

Nature of Mortars.		Calibre.	Length of Mortar.	Length of Bore.	Weight.	Chamber. Length.	Chamber. Diameter. Superior.	Chamber. Diameter. Inferior.
		Inches.	Inches.	Inches.	Cwts. qrs. lbs.	Inches.	Inches.	Inches.
Land Service	13-Inch . . Iron.	13·0	36·563	26·0	36 20	13·0	13·0	7·5
	10 do. do.	10·0	28·125	20·0	16 2	10·0	10·0	5·0
	8 do. do.	8·0	22·5	16·0	8 2 14	8·0	8·0	4·0
	$5\frac{1}{2}$ do. Brass	5·62	15·104	11·943	1 1 15	5·62	5·62	3·1
	$4\frac{2}{5}$ do. do.	4·52	12·713	10·17	3 20	5·52	5·52	2·7
Sea Service	13-Inch . . Iron	13·0	52·81	39·0	100 1 14	13·0	9·75	7·312
	10 do. do.	10·0	45·62	35·0	52	10·0	7·5	5·64

GENERAL RULES FOR MORTAR PRACTICE AT FORTY-FIVE DEGREES ELEVATION.

The following general rules for computing the charges, times of flight, &c., have been deduced from the tables of 1793, which are generally considered more accurate than any of those of later date.

1. *To find the Charge of Powder for a given Range.*

1. For the 13-inch.—To the range, in yards, add half the range, and multiply the sum by ·03, for the charge, in ounces.

2. For the 10-inch.—When the range is under 1350 yards, add 160, and multiply by ·02; and when it exceeds 1350 yards, add one-fifth of the range, and multiply by ·02, for the charges, in ounces.

3. For the 8-inch.—To the range, in yards, add 20, and the product of that sum and ·015, will give the charge, in ounces.

4. For the $5\frac{1}{2}$-inch.—Add 150 to the range, in yards, and multiply by ·08, for the charge, in ounces.

5. For the $4\frac{2}{5}$-inch.—To the range, in yards, add 300, and multiply by ·06, for the charge, in drachms.

To find the Time of Flight, the Range being given.

Divide the square root of the given range, in feet,

by 4·5, and the quotient will be the time of flight, in seconds.

The rule for finding the length of fuze will be found under the head of Fuzes.

OBSERVATIONS ON THE EMPLOYMENT OF MORTARS.

The principal advantages to be derived from the employment of mortars, may be reduced to the three following heads :—

1. At a siege, to bombard the town, and dismount the enemy's artillery.

2. To set fire to and overthrow the works; and produce havock and disorder among the troops.

3. To break through the vaulted roofs of barracks, magazines, casemates, &c. which have not sufficient strength to resist the shock.

The 10-inch mortars are generally adequate to these purposes; hence, on principles of economy, 13-inch mortars are seldom used, except when the ranges exceed the powers of the 10-inch. The figures of these mortars being precisely the same, their longest ranges are in the ratio of 4 to 5 nearly. The 13-inch however, has a decided advantage, when employed, for setting fire to buildings, &c., from the superior capacity of its shells, and for that reason a mortar of this description invariably forms a part of the armament of every bomb vessel :—the splinters from its

shells are very destructive; and the harsher the metal, and more uniform its thickness, the greater will be their number.

In the larger mortars, the initial velocity of the shell increases in proportion to the charge; hence, to obtain the greatest range, the chamber should be filled with powder, a tompeon of wood placed over it, and both the tompeon and shell surrounded with sifted earth or sand; that from the increase of resistance, the inflammation of the powder may be more instantaneous and rapid, and the fluid more abundant and elastic. An increase of elevation also adds to the initial velocity, even with equal charges, since, from the greater resistance opposed to the explosion, in this position of the mortar, the fluid generated in the chamber acquires a greater degree of density before the shell begins to move.

By varying the charge of powder in the same mortar, it has been found that there is a particular elevation which, with each charge, gives a longer range than can be obtained from the same charge at any other elevation; and that the elevations which give the longest ranges, differ very materially in two mortars of different calibres, but of similar proportions, and charged with quantities of powder proportionate to the weights of their respective shells, and to the capacities of their respective chambers. See the words Trajectory and Projectiles.

MORTAR-BEDS.

Weight and Dimensions of Land and Sea Service Mortar Beds.

Nature of Bed.	Weight.			Dimensions. Length.		Breadth.		Height.		Tonnage.		
	Cwts.	qrs.	lbs.	Ft.	In.	Ft.	In.	Ft.	In.	Cwts.	qrs.	lbs.
13-Inch Sea Service.... Iron.	83	2	8	7	2·5	4	7·5	3	3·5			
13-Inch Land Old Pattern do	48	3	11	5	8	3	4	2	1			
13-Inch Land New do. do	33		1	5	5·5	3	10·5	2	1			
10 do. Sea Service.... do.	55	2	2	7	1	3	8	2	9·5			
10 do. Land Old Pattern do.	21	3	19	4	5	2	7	1	7			
10 do. Land New do. do.	16	1	16	4	4	3	4·5	1	7			
8 do. Land Old Pattern do.	11	1	10	3	6	2	1	1	3			
8 do. Land New do. do.	7	2	27	3	3	3	1	1	3			
$5\frac{1}{2}$ do. Do.......... Wood	1		10	2	7	1	3		9			
$4\frac{2}{5}$ do. Do.......... do.		3		2	5	1	3		8·5			

The above Weights of the Sea Service Beds include the Pintails, each of which weighs 2 cwts. 2 qrs. 20 lbs., and the breadth and length of each Bed, for both Services, is measured from the extremities of the traversing bolts.

MOTION (Laws of).

There are three general laws of motion, viz.:—

1. Every body, if at rest, continues in a state of rest, or, if put in movement by an impulse, it continues in a state of uniform motion in a rectilinear direction, until a change is effected by the agency of some mechanical force.

2. Every change effected in the state of a body, whether that state be rest or motion, is in the direction of the force impressed upon, or soliciting it; and also, is proportional to the quantity of the acting force.

3. When any body acts mechanically upon another, the latter exerts an equal and contrary action on the former body.

Uniform Rectilinear Motion.

Uniform motion is produced by a single impulse communicated to a body, and the velocity of a body in motion being measured by the space uniformly described in a given time, it follows that, when a body moves with an uniform motion, the spaces it describes are proportional to the times.

But if several bodies move with different velocities, during different times, the spaces they describe are proportional to the velocities multiplied into the times of motion respectively; which is expressed by the formula $S \propto v \cdot t$.

Accelerated Rectilinear Motion.

Accelerated motion is the result of the continued action of a moving power on a body subject to its influence, and it may be considered as produced by a succession of equal impulses at the end of indefinitely small portions of time. Each new impulse producing an equal increment of velocity, the velocity at the end of any given time will be proportional to the time; the spaces described in the successive instants of time will form a series of terms in arithmetical progression, beginning with zero, and increasing by unity, and the sum of such a series is equal to the whole space described. But the same space would have been described in the same time, if the body had moved uniformly with a velocity which is a mean of all the variable velocities, and that mean velocity is half the greatest, which may be represented by half the time of motion. Therefore, substituting this expression for the velocity, in the formula of uniform motion; viz. $S \propto v.t.$ we have $S \propto \frac{1}{2} t^2$; whence $S \propto t^2$. That is, the spaces described by a body urged by an accelerative force are proportional to the squares of the times of motion.

Near the surface of the earth a body falls through $16\frac{1}{12}$ feet by the action of gravity in one second of time; therefore, the spaces described by a falling body in any given time may be found by the formula, $S \propto t^2$.

And the velocity generated in a body urged by the action of gravity during one second, being such as

would carry the body through 16^1 feet in the same time if the body had moved uniformly with half that generated velocity, twice that space, or $32\frac{1}{6}$ feet, will express the velocity generated by gravity at the end of one second, and we may find the velocity generated at the end of any given time by the formula $S \propto v$.

But when different bodies move with unequal accelerative forces; then, because the spaces described and the velocities generated are directly proportional to the forces, and inversely proportional to the masses or weights of the bodies; the spaces and velocities due to given times may be found by the formula $S \propto \frac{f. t^2}{m}$, and $v \propto \frac{f. t.}{m}$

Retarded Rectilinear Motion.

When a body in motion is retarded by a constant force, the space described before the motion is extinguished is evidently equal to that described by a body, moving from a state of rest, by an accelerative force, till it acquires a velocity equal to that with which the retarded body began its motion. Therefore, in retarded motions, the space described by a body before motion is destroyed, is proportional to the square of the initial velocity. But when there are different bodies subject to different retarding forces, the spaces described must be inversely proportional to the forces, and directly proportional to the masses

or weights of the bodies. Therefore,the space described before motion is extinguished may be found by the formula $S \propto \frac{m.v^2}{f}$. And the time in which the motion is extinguished may be found from the formula $t \propto \sqrt{S}$.

Hence may be found, both the spaces described, and the velocities lost in given times, when a moving body is subject to a retarding force.

ORPIMENT.

There are two descriptions of this mineral, red and yellow.

Red Orpiment is the produce of Sicily, Hungary, Transylvania, and various parts of Germany. It is either massive or crystallized. The primitive form of the crystals is octoedrical, with scalene triangles which seem to be the same with the primitive form of sulphur, and they commonly appear in four, six, eight, ten, or twelve-sided prisms, terminated by four-sided summits. Colour, aurora-red, streaked lemon, or orange yellow. It burns with a blue flame and soon evaporates.

Yellow Orpiment is procured from Hungary, Wallachia, Georgia, and Turkey in Asia. The crystals are confused, and their figure cannot be easily determined. Some of them appear to be octahedrons, and others minute foursided prisms. Colour, a translucent lemon yellow. Yellow orpiment burns with a blueish white flame.

OSCILLATION (Centre of).

When a body, or system of bodies vibrates about an axis of suspension, with a certain angular velocity by the action of gravity, then that point in the axis of the body or system in which a particle being suspended from the axis of motion will vibrate with the same angular velocity, is called the centre of oscillation of the body or system.

To determine this point, imagine the line joining the centres of suspension and oscillation to be oblique to the vertical position;—then the force of gravity upon any particle or body in the system, to turn it about the point of suspension, which is equal to the mass of the particle multiplied into the distance of the point of suspension from a vertical line passing through the particle, may be found, and, consequently, the sum of the actions of gravity upon all the particles or bodies. Also, let the force of gravity upon a particle in the centre of oscillation be found in the same way.

Next, the momentum with which any particle or body of the system, in vibrating, resists the action of gravity may be found, since it is equal to the mass of the particle or body, multiplied into the square of its distance from the centre of suspension, and the sum of all such momenta may consequently be obtained; also, the momentum with which a particle placed at the centre of oscillation resists the action of gravity.

Then, in order that the angular velocities of the vibrating system, and of the particle in the centre of

oscillation may be equal, the ratios of the actions of gravity to the resistance, must be the same in both cases; and by making a proportion of the four terms, the unknown quantity, which is the distance of the centre of oscillation from the point of suspension, may be found.

The result is, that the place of the centre of oscillation in any body is coincident with the centre of percussion, except in certain cases of rare occurrence.

Cor. In any vibrating body, if the centre of oscillation be made the point of suspension, that which was before the point of suspension becomes now the centre of oscillation.

In a right line or slender rod suspended from one of its extremities, the distance of the centre of oscillation, or of percussion from the point of suspension, is equal to $\frac{2}{3}$ of the length of the rod.

In an isosceles triangle vibrating about a line parallel to its base, and passing through its vertex; the distance of the centre of oscillation, or of percussion from the point of suspension, is equal to $\frac{3}{4}$ of the length of a perpendicular let fall from the vertex upon the base.

In a slender pyramid or cone suspended from its vertex, the distance of the centre of oscillation, or percussion from the point of suspension, is equal to $\frac{4}{5}$ of the perpendicular height.

In a circle attached by a slender rod or string to the point of suspension, and vibrating in its own plane,

the distance of the centre of oscillation from the point of suspension, is equal to the sum of the distance from the point of suspension to the centre of the circle, and of the quotient arising from the square of the radius divided by twice that distance.

It has been proved, that the distance of the centre of gravity from the centre of oscillation, or percussion, is inversely proportional to the distance of the centre of gravity from the point of suspension. Therefore, knowing the position of the centres of gravity and oscillation in any vibrating body, (as a right line,) and, having found the centre of gravity of any given body, mechanically or otherwise, the centre of oscillation, or percussion of this latter body can be found by simple proportion. Or, find a simple pendulum which shall perform its vibrations in the same time that the given pendulous body performs its vibrations; the length of the simple pendulum is equal to the required distance of the centre of oscillation from the point of suspension. Or, lastly, the place of the centre of oscillation may be found by the law of the vibration of pendulums, taking for datum that a simple pendulum $39\frac{1}{6}$ inches long performs one vibration in a second of time.—See the word PENDULUM.

PACE.

The pace is an uncertain lineal measure, usually reckoned at 2 feet 6 inches. The geometrical pace is by some persons supposed equal to 4·4 feet, by others 5 feet, and 60,000 of these last make one degree on the equator.

In Germany, and among most of the Northern Powers, it is considered equal to two-tenths of a Rhynland rood.

In France, as in England, the pace is commonly reckoned at 2 feet 6 inches.

Table for Reducing the Common Pace of Two Feet Six Inches, into Feet and Inches:—

Paces.	Feet.	Inches.	Paces.	Feet.	Inches.	Paces.	Feet.	Inches.	Paces.	Feet.	Inches.	Paces.	Feet.	Inches.	Paces.	Feet.	Inches.
1	2	6	26	65	0	51	127	6	76	190	0	101	252	6	126	315	0
2	5	0	27	67	6	52	130	0	77	192	6	102	255	0	127	317	6
3	7	6	28	70	0	53	132	6	78	195	0	103	257	6	128	320	0
4	10	0	29	72	6	54	135	0	79	197	6	104	260	0	129	322	6
5	12	6	30	75	0	55	137	6	80	200	0	105	262	6	130	325	0
6	15	0	31	77	6	56	140	0	81	202	6	106	265	0	131	327	6
7	17	6	32	80	0	57	142	6	82	205	0	107	267	6	132	330	0
8	20	0	33	82	6	58	145	0	83	207	6	108	270	0	133	332	6
9	22	6	34	85	0	59	147	6	84	210	0	109	272	6	134	335	0
10	25	0	35	87	6	60	150	0	85	212	6	110	275	0	135	337	6
11	27	6	36	90	0	61	152	6	86	215	0	111	277	6	136	340	0
12	30	0	37	92	6	62	155	0	87	217	6	112	280	0	137	342	6
13	32	6	38	95	0	63	157	6	88	220	0	113	282	6	138	345	0
14	35	0	39	97	6	64	160	0	89	222	6	114	285	0	139	347	6
15	37	6	40	100	0	65	162	6	90	225	0	115	287	6	140	350	0
16	40	0	41	102	6	66	165	0	91	227	6	116	290	0	141	352	6
17	42	6	42	105	0	67	167	6	92	230	0	117	292	6	142	355	0
18	45	0	43	107	6	68	170	0	93	232	6	118	295	0	143	357	6
19	47	6	44	110	0	69	172	6	94	235	0	119	297	6	144	360	0
20	50	0	45	112	6	70	175	0	95	237	6	120	300	0	145	362	6
21	52	6	46	115	0	71	177	6	96	240	0	121	302	6	146	365	0
22	55	0	47	117	6	72	180	0	97	242	6	122	305	0	147	367	6
23	57	6	48	120	0	73	182	6	98	245	0	123	307	6	148	370	0
24	60	0	49	122	6	74	185	0	99	247	6	124	310	0	149	372	6
25	62	6	50	125	0	75	187	6	100	250	0	125	312	6	150	375	0

The common pace of 2 feet 6 inches, is to that of a horse, as 10 to 7; that is 70 paces of a horse are equal to 100 common paces.

For the military pace, see the word MARCHING.

PALISADES

Are 9 feet long, and 6 or 7 inches square. When fixed, they are generally planted 3 feet in the ground and about 3 inches asunder.

See the word FORTIFICATION.

PARALLELS.

The parallels, or places of arms, are trenches formed to connect together the several approaches of a besieged place.

See the word TRENCHES.

PARK OF ARTILLERY.

The artillery should always be parked, if possible, in an open situation, with easy access to the road, and where it is not likely to interrupt the communications of the other troops. The form of the park must depend upon its situation; ten feet, in front, are usually allowed for each carriage and its interval, and about fifty feet in depth, from the axle-tree of the gun limber to that of the body of the ammunition waggon. The distance, however, between the line of guns, and that of their waggons must depend upon the number

of horses attached to each carriage, and should allow sufficient space for putting them to, and at the same time for a free passage along the line.

In parks, not on immediate service, it is customary to arrange the guns with their muzzles to the front; but where the guns are likely to be wanted at a short notice, appearances must not be studied, and the carriages should be parked with their shafts to the front, ready to receive the horses to them.

A quarter guard is posted in front of the park, and the non-commissioned officers' and gunners' tents on the flanks, at about twenty paces distance: at forty paces, to the rear, the subalterns', and at ten more the captains' tents are pitched. The tent of the commanding officer is pitched at twenty paces in rear of the captains', and the mess tent, at fifteen paces in rear of the commanding officer's. At a convenient distance in rear of the whole, the horses are picketed, in one or more lines, with the drivers on their flanks.

When the depth of the ground, or other circumstances, will not admit of this arrangement, the horses are picketed in lines perpendicular to the front, between the non-commissioned officers' and gunners tents, and the carriages.

See the word CAMP.

PENDULUMS (Vibration of).

It is proved by dynamics, that a body, descending down an inclined plane by the force of gravity, acquires

the same velocity as by descending vertically down a space equal to the height of the plane; and the same is proved of a body descending down any system of inclined planes, or down the concave surface of any arc of a curve. And the motion of a pendulous body about its point of suspension being identical with that of a body rolling down the concave side of a circular arc, the radius of which is equal to the distance of the pendulous body from the point of suspension, it follows that such a body will acquire the same velocity, in the lowest point of the curve it describes, that it would have acquired by falling vertically through a space equal to the versed sine of half the arc of vibration.

If, therefore, two pendulums describe equal angular spaces about the point of suspension, their velocities, in the lowest point of the arcs they describe, will, by the laws of accelerated rectilinear motion, be proportional to the square roots of the versed sines of the arcs. Or, the arcs being similar, the versed sines are proportional to the arcs or to their radii. Therefore, the velocities of the pendulous bodies, in the lowest points of the curves, are proportional to the square roots of the lengths of the pendulums. Or the velocity acquired by descending down a vertical line, being proportional to the time of descent, the time of a vibration will be proportional to the square root of the length of the pendulum, or the lengths of pendulums are proportional to the squares of the times of vibration.

The length of a pendulum is to be estimated by the distance of its centre of oscillation from the point of suspension.

From the experiments of Captain Sabine, the lengths of pendulums, vibrating seconds, in different parts of the earth, are as exhibited in the following table:—

Names of places.	*Lat.*		*Length of pendulum.*	
At the Equator ..	0° 0′		39·01520	Eng. inches.
At Trinidad......	10° 38′	North	39·02211	do.
At Jamaica	17° 56′	do.	39·03440	do.
At New York....	40° 42′	do.	39·10133	do.
At London........	51° 31′	do.	39·13926	do.
At Unst	60° 45′	do.	39·16934	do.
At Hammerfest....	70° 4′	do.	39·19546	do.
At Spitzbergen....	79° 50′	do.	39·21134	do.

BALLISTIC PENDULUM.

The ballistic pendulum is a block of wood attached to one extremity of a rigid bar, and capable of vibrating about a horizontal axis at the other extremity. A spear projects downwards from the lowest part of the block, and moves, during the vibration, in a groove formed in a circular arc, the centre of which is in the axis of vibration. This groove is filled with a composition of wax and soap; and a mark, made by the extremity of the spear on the surface of the composition, shews the extent of the vibration.

The block being made to vibrate by the impact

of a shot discharged against it, the velocity with which the shot strikes the block may be determined in the following manner.

Let the centres of gravity, oscillation, and gyration of the pendulum be found; and, by the rules of dynamics, reduce the mass or weight of the pendulum to that which, if it were collected in the point of impact of the shot, would receive the same angular velocity from the force of impact which the given pendulum would receive, if its mass were accumulated in the centre of gyration. Then, because the shot is supposed to remain in the block after impact, the mass of the former is to be added to this reduced mass of the pendulum, in order to express the whole mass moved by the impact of the shot. Now the momentum of the shot is equal to its mass, or weight, multiplied by the velocity it obtains from the force of the powder. Therefore, by the laws of the collision of non elastic bodies, the momentum of the shot, divided by the whole mass moved, gives an expression for the velocity of the block after impact, estimated at the point where the shot strikes it.

But, from the arc described by the point of the spear, the corresponding arc, described by the centre of oscillation of the block and ball together, may be found. And, by the laws of vibrations of simple pendulums, we can, from thence, find the velocity of the centre of oscillation at the lowest point of the arc; and, from that, by proportion, the velocity of the point of im-

pact, at the moment the block was struck by the shot. This is equal to the former expression for its velocity; and, from the equation thence arising, we obtain the unknown quantity, which is the velocity of the ball.

With the same pendulum, and the same weight of ball, the velocity of the latter it directly proportional to the versed sine, or to the chord of the arc described by the centre of oscillation of the pendulum.

The ballistic pendulum is also employed to ascertain the strength of the composition of a rocket, by attaching the latter to the face of the pendulum, perpendicularly to the vertical axis, and in the plane of motion; and observing the angle which the axis of the pendulum makes with a vertical line at the instant the rocket ceases to burn.

MOORE'S TREATISE ON THE MOTION OF ROCKETS.

PENETRATION (of Shot).

When a cannon shot is discharged against any material, such as timber or earth, it penetrates to a certain depth before the resistance of the material stops its motion; and, from the theory of forces, Dr. Hutton gives the following equation between the resisting force of the material, the velocity of the shot, and the depth penetrated; viz.—$f = \frac{v^2}{4 g s}$; where $f =$ the resisting force, $s =$ the penetration, in feet, and $g = 16$ feet; and, from a mean of several experiments on the

resistance of elm timber, he makes $f = 17{,}000$ times the force of gravity, for that material. Dr. Hutton also shews that oak resists more than elm, in the ratio of 19 to 17, or that for oak, $f = 19{,}000$, and that elm resists more than earth, in the ratio of $7\frac{1}{3}$ to 1, or that, for earth, $f = 2320$ nearly. Again he shews that the depth of penetration is proportional to $\frac{d.\,D.\,v^2}{f}$; where $d =$ density of the ball, $D =$ its diameter, $v =$ the velocity of the shot, and $f =$ the force of resistance.

To produce the greatest damage to any splintering object, as oak, by a shot fired against it, the shot fired should lose all motion just as it ceases to be resisted by the object, which happens when the shot has forced its first hemisphere out of the further surface of the object. And the charge necessary to produce the greatest effect when a shot is fired against such object, the side of a ship, for example, may be found by the following formula, viz.—$C = 0{\cdot}045\frac{S \cdot W}{D}$; where $C =$ the charge, $W =$ the weight of the ball, both in pounds, $S =$ the thickness of the side of the ship, and $D =$ the diameter of the shot, both in the same denomination.

If the shot is required to pierce both sides of the ship, and the greatest damage is to take place on the farthest side, make S, in the above equation, equal to double the thickness of the side, and find the charge accordingly. This, Mr. Moore thinks, would be the

most advantageous practice, on account of the chance of the ball striking the mast of the ship.

From data afforded by experiment, Mr. Moore obtains the following formula to determine the charge necessary to enable a shot of given weight and diameter just to penetrate through a bank of dry earth, the thickness of which is also given, viz.—$C = 0{\cdot}01012 \frac{S \,.\, W}{D}$; where $S =$ the thickness of the bank, and $D =$ the diameter of the shot, both in the same denomination; $C =$ the charge, and $W =$ the weight of the ball, which will also be both of the same denomination.

MOORE'S ESSAY ON NAVAL GUNNERY.

PERCUSSION (Centre of).

When a body or system of bodies either vibrates or revolves about an axis or point of suspension, and meets an immoveable object in a point so situated that, after impact, the body or system becomes quiescent, or has no tendency to turn about the point of impact, that point is the centre of percussion.

The determination of this point depends on the sum of the momenta of all the points above it, being equal to the sum of all below it.

Imagine a line drawn from the point of suspension, through the centre of percussion, then the momentum of one of the points or bodies will be expressed by its mass multiplied into its distance from the point of suspension, and its momentary effect will be in the direction of a tangent to the circle it describes about

the point of suspension. This momentum being estimated by the resolution of forces, in a direction perpendicular to the line joining the points of suspension and percussion, and multiplied into the distance of its point of application from the latter (which point of application is where the tangent meets the said line), will express the effect to turn the system about the centre of percussion.

In the same manner the actions of all the other points or bodies in the system may be found; and, as the whole system is to be quiescent after impact, the sum of all these actions must be made equal to zero. And, from the equation thence resulting, the unknown quantity, which is the distance from the point of suspension to that of percussion, may be found.

PETARDS.

An experiment was made at Woolwich, in 1826, with a petard, containing 9 pounds, and, also, with a leather bag, containing 50 pounds, of powder, for the purpose of ascertaining their relative values, in bursting open town gates, barriers, &c. The result of the experiment was as follows:—

The petard occupied six men nearly twenty minutes in fixing it to the gates, and, when exploded, merely made a hole through them, as if they had been struck by a shot from a 6-pounder. The leather bag was fixed by two men in five minutes, and perfectly succeeded in forcing open the gates.

PLATFORMS.

Weights and Dimensions of Platforms for Guns, Howitzers, and Mortars.

NATURE OF PLATFORM.	Number.	Oak. Dimensions. Length. Ft.	In.	Breadth In.	Thickn. In.	Oak. Weight. cwt.	qr.	lbs	Fir. Dimensions. Length. Ft.	In.	Breadth In.	Thickn. In	Fir. Weight. cwt.	qr.	lbs
Guns and Howitzers. Madras. Common. Sleepers	5	14		6	6										
Hurters	1	8		10	10										
Planks	14	11		12	2·5										
Pickets	20														
Total Weight															
Original. Sleepers .. Front	1	7	7	9	7·5	1	3		7	7·5	9	9	1	1	23
Sleepers .. Centre	1	8	10·5	9	7·5	2		26	9		9	9	1	2	21
Sleepers .. Rear	1	11	1	9	8	3	2	4	11		9	9	3	1	23
Traversing Brace	1	7	3	11·5	3·75		3	25	7		11·5	4		2	15
Planks... Right	1	17	6	11·5	3·75	2	1	10	17	5	11·5	4	2		25
Planks... Centre	1	18	9	11·5	3·75	2	1	22	18	6	11·5	4	2		20
Planks... Left	1	17	6	11·5	3·75	2	2	1	17	5	11·5	4	2		8
Total Weight						15	3	4					13	2	23
Modified. Garrison. Planks	2	18		12	3	2	1								
Sleepers Front	1	7		9	9	1	3	8							
Sleepers Centre	1	8	2	9	9	2	1	1							
Sleepers Rear	1	10		10	9	2	3	26							
Traverse Boards	1	5	10	9	3		2								
Total Weight						9	3	7							
Modified. Travelling. Sleepers Front	1	7		9	9	1	3	8							
Sleepers Centre	1	8	2	9	9	2	1	1							
Sleepers Rear	1	10		10	9	2	3	26							
Planks	2	17	6	12	3										
Trail .. Plank	1	18		12	3										
Trail .. Block	1	3		7	10										
Total Weight															
Mortars.. Planks	13	13	6	10	2·5										
Mortars.. Sleepers	5	9	3	8	8										
Mortars.. Total Weight															

The usual slope of platforms for guns and howitzers is one inch to every yard. Mortar platforms are laid perfectly horizontal.

PLUMMETS.

The following lengths of plummets, for regulating the several degrees of march, are taken from the Field Exercise and Evolutions of the Army, as revised and corrected by Major-General Sir Henry Torrens, K.C.B., and K.T.S., Adjutant-General to the Forces.

Slow-time........	75 paces in a minute,		24·96 inches.
Quick-time......	108	ditto	12·05 ditto.
Wheeling-time..	120	ditto	9·8 ditto.
Double-march ..	150	ditto	6·26 ditto.

A musquet ball, suspended by a piece of silk, or string, not subject to stretch (which must, of course, be kept perfectly dry), and on which the required lengths are marked, will answer the above purposes. The length of the plummet is to be measured from the point of suspension to the centre of the ball.

POINT-BLANK.

A piece of ordnance is said to be laid point blank for an object when the axis of the gun and the object are in the same plane, which may be either parallel or inclined to the horizon. Hence, the point blank range of a piece of ordnance, *or its range at no elevation*, is the distance from the muzzle of the gun to the first graze measured upon a plane passing under the wheels, and parallel to the axis of the bore.

See the word Elevation.

PONTOONS.

Weight and Dimensions of Pontoons and their Apparatus.

	DESCRIPTION OF PONTOONS.	Number.	Dimensions. Length.		Breadth.		Thickness		Weight.		
			Ft.	In.	Ft.	In.	Ft.	In.	cwt.	qr.	lb.
Old Pontoons.	Pontoon, Tin	1	21	6	4	9	2	3	9	1	24
	Carriage	1							12	3	19
	Chesses	8	11	6	2	4		1·5	9		16
	Baulks	6	22	8		4·5		4·5	4	1	4
	Gang-boards	1	22		1			2·25	1		18
	Oars	2	14								22½
	Boat-hooks	1									12
	Setting-poles	1									13½
	Park-pickets	2									25
	Graplins	1								1	15½
	Anchors	1								1	24
	Buoys	1									13
	Coupling Bolts and Keys	6									13
	Blocks, 8-Inch	2									14½
	Cable, 3-In. faths.	86							2	1	6
	Lashings 2 In. do	12½									22
	Lashings 1½ do.	37½									13½
	Total Weight								41	1	23½
Major Blanchard's.	Pontoons, Cylindrical, Tin	2	21		2	6	2	6	7		
	Carriage	1							12	1	8
	Gun-wales	2	11	11		3·5		2·5	1	1	15
	Chesses	10	11	5	2	1		1·5	8	1	12
	Baulks	12	11	11·5		5		2·5	3		22
	Oars	7	14							3	17
	Boat-hooks	1	14								11
	Anchors	2							1		
	Ropes of sorts								1	2	14
	Total Weight								25	3	5

Pontoons.—Continued.

	Description of Pontoons.	Number.	Dimensons.						Weight.		
			Length.		Breadth.		Thickness				
			Ft.	In.	Ft.	In.	Ft.	In.	cwt.	qr.	lb.
Sir James Colleton's.	Pontoon, Cylindrical, Wood.	2	22	9	2	4½	2	4½	8	2	20
	Carriage	1							12	1	8
	Gun-wales	2	12			3¼		3	1	1	24
	Baulks.	12	11	4		4¾		3	4	1	26
	Chesses, Large.	8	11	3	2			1½	6	2	10
	Chesses, Small.	2	11	3	1	6		1½	1	1	10
	Steerage-boards.	1	11	6		11		1½		1	19
	Oars	8	14							3	27
	Gun-wale Straps	24									9
	Boat-hooks....	1	14								11
	Ropes of Sorts.								1	1	6
	Anchors	2							1		
	Total Weight ..								38	3	2
Colonel Pusley's.	Pontoons, each in two parts, Copper	2	22		2	8	2	8	12		
	Carriages......	2							26		
	Baulks. For various purposes.	14	14			4½		3	5	3	5
	Gun-wales	2	14			4		3	1	2	4
	Transoms......	2	14			4½		4		3	16
	Chesses, Large.	8	11	6	2	9		1½	10		2
	Chesses, Small.	4	11	6	1	4½		1½	2	2	2
	Gauge-sticks, or Dividers..	2	14			2¾		1¾			20
	Oars..........	6	14							3	5
	Boat-hooks....	1	14								11
	Anchors	2							1		

PONTOONS.—Continued.

DESCRIPTION OF PONTOONS.		Number.	Dimensions. Length. Ft. In.	Breadth. Ft. In.	Thickness. Ft. In.	Weight. cwt. qr. lb.
Colonel Pasley's	Bolts Large ..	4				7
	Bolts Small ..	4				5
	Rudders	1				13
	Shovels	1				5
	Picks	1				9
	Pumps, Copper.	1				5
	Lashings, Webb.	8				11
	Rack - sticks, &c	8				12
	Buoys, Copper ..	2				11
	Mops	1				2
	Ropes of sorts ..					1 10
	Total Weight ..					62 2 19

A committee of Artillery, and Engineer officers were, in 1826, ordered to report upon the above pontoons; and their award was in favour of those of Major Blanchard's construction.

PORTFIRES.

The papers for forming portfire cases are 19 inches long by 10·5 inches in breadth. The drifts, of which there are four, are ·425 of an inch in diameter; and 17·8, 12·6, 7·5 and 4·2 inches in length respectively. Their handles are 1·4 of an inch long, and ·8 of an inch in diameter. The weight of the mallet is 1 lb. 10 ozs., and the copper ladle contains 1 drachm.

Composition.—Saltpetre, 6 pounds; sulphur, 2 pounds; and mealed powder, 1 pound.

These ingredients should be thoroughly incorporated; first, by rubbing them between the hands for 10 or 12 minutes, and afterwards by passing them 3 or 4 times through a fine hair sieve.

The following are the Proportions of Materials required for Preparing the undermentioned Numbers of each Description of Portfires:—

DESCRIPTION OF MATERIALS.		For Making		
		1000 Long small Portfires.	500 Miner's Portfires.	100 Blue Portfires.
Paper, Rms. qrs. sheets.	Portfire	2 4 4		
	Brown	0 0 10	0 0 5	
	White, Fine		0 3 12	
	Blue Sugar-loaf			0 4 4
Saltpetre, lbs. oz.	Pulverized	168 0	2 8	
	Refined			0 12
Sulphur, lbs. oz.	Sublimed	56 0		
	Refined		2 8	
Powder, Mealed, lbs. oz.		31 0	5 0	
Thread, Pack, Common, lb. oz.		1 0		0 1½
Spirits of Wine, Pints		¾		
Copperas, ozs.		4		
Oil, Linseed, Raw, Pints		3		
Paint, lb. oz.	Dry Lamp Black	0 0½		
	Ground in Oil, White Lead	12 0		
Flour, lbs. oz.		11 4	0 4	0 2
Twine, Packing			0 0¼	

PROJECTILES (Resistance of the Air to).

The results of experiments formerly made at Woolwich have shewn, that the resistance of the atmosphere to the motion of shot, is nearly proportional to the squares of the velocities, when the shot are equal in diameter and weight, and when the velocities are less than 300 feet per second; but when the velocities are greater than this, the resistance is in a higher ratio than the squares of the velocities, gradually increasing with them. When the shot are of equal specific gravities, but of unequal diameters, and move with equal velocities, the resistance is nearly proportional to the surfaces, or to the squares of the diameters, but in a higher ratio, when the velocities are considerable.

From experiments on the motion of an iron shot of 1·965 inches diameter, and 1·401 lbs. weight, with different initial velocities, from 300 to 2000 feet per second, Dr. Hutton found the resistance nearly proportional to the 2·1 power of the velocity; but this term not being convenient, he assumed the resistance equal to $M. v^2 \times N. v$; where M and N are indeterminate co-efficients of the velocity (v) the values of which are obtained by making this expression equal to the resistances determined by experiment with two different velocities. From the two equations thence arising, we have $M = \cdot 00002665$, and $N = -\cdot 004025$, whence the resistance of the atmosphere against that

ball, expressed in avoirdupois pounds, is $\cdot00002665\ v^2 - \cdot004025\ v$.

When the velocity is less than 300 feet per second, the resistance is expressed by $\cdot00001765\ v^2$.

To adapt these theorems to balls of any other size, they must be altered in the ratio of the squares of the diameters of the balls; which reduces the former theorem to $\{\cdot000007565\ v^2 - \cdot00175\}\ d^2$, and the latter to $\cdot0000044\ d^2 v^2$; d being the diameter of the given ball.

When a ball is fired vertically upwards, the weight of the ball is to be added to the terms, expressing the resistance, in order to give the whole resistance to the ball's motion; but the inertia of the ball is a force opposing the action of the air against it, and this inertia is proportional to the weight of the ball. Therefore the retarding force is expressed by $\frac{(M.v^2 - N.v)d^2 + W}{W}$, where $M = \cdot000007565$, $N = \cdot00175$, and $W =$ the weight of the ball in pounds. And this being substituted for f, in the fluxional formula for variable motions; viz. $v.\dot{v} = 2\,g.f.\dot{s}$; there is obtained by integration, the formula $669\ d \times$ com. log. $\frac{v^2 - 231\cdot5\ v + 18600\ d}{18600\ d}$, for the space described, or the altitude to which an iron ball, of which d is the diameter, and v the initial velocity, will ascend vertically in the air.

In this fluxional formula, $v =$ the initial velocity, $g = 16\frac{1}{12}$, feet, $f =$ the retarding force, and $s =$ the space ascended.

When a ball descends in the atmosphere from a state of rest, it is evident that the motion begins, and increases by the weight of the ball, which is the constant accelerating force, and would produce an equal increase of velocity in equal times, if it were not for the diminution of motion caused by the air's resistance. But this resistance begins with nothing, and continually increases, in proportion to the square of the velocity of the ball, nearly.

It is evident therefore, that, as the accelerating force is always the same, and the resistance always increasing, it must happen that the latter will, at length, become equal to the former. When this takes place, there can, afterwards, be no further acceleration of the motion, the impelling force and the resistance being equal to each other, and the ball must, ever after, descend with an uniform motion. The velocity which the ball has, when its motion becomes uniform, is called its terminal velocity.

Since the resistance of the air is to be equal to the accelerative force, that is, to the weight of the ball, substitute in the formula of resistance, viz.—

$\left\{ \cdot 000007565\ v^2 - \cdot 00175\ v \right\} d^2$, the value of d,

that is, the diameter of the ball, and make the result equal to the weight of the ball, in pounds; then from

this equation may be obtained the value of v, which is the terminal velocity required.

As the above formula of resistance is adapted to solid iron balls only, the result must be modified when the balls are of lead, or when shells are used. Shells filled with powder have less weight than iron balls of equal diameters in the proportion of 1 to 1·42; therefore, the power to oppose the air's resistance will be less in the same ratio, and the terminal velocity will be less in the ratio of 1 to $\sqrt{1 \cdot 42}$, or of 1 to 1·19. Consequently, having found the terminal velocity for a solid iron ball of the same diameter as the shell, by the above rule, divide it by 1·19, and the quotient will be the required terminal velocity of the shell.

PROOF.

For the mode of proving gunpowder, see that word. The following are the regulations for the

PROOF OF ORDNANCE.

All natures of ordnance undergo several kinds of proof before they are received into His Majesty's service, viz.:—

1. They are gauged as to their several dimensions, internal and external, viz.—the coincidence of the axes of the bore and metal, and the positions of the chamber, vent, trunnions, &c.

2. They are fired with a regulated charge of powder and shot, and afterwards searched to dis-

cover if any irregularities or holes are produced by the firing.

3. An endeavour is made, by means of engines, to force water through them; and,

4. They are examined, internally, by means of light reflected from a mirror.

Iron Guns.

The guns are first examined as to their proper dimensions. In the length there is in no case allowed a variation exceeding 0·3 of an inch; in the diameter of the bore, only ·033 of an inch from a 42-pounder to an 18-pounder, and ·025 of an inch from a 12-pounder to a 4-pounder; and in the position of the bore, ·25 of an inch out of the axis from a 42-pounder to an 18-pounder, and ·334 of an inch from a 12-pounder to a 4-pounder is allowed. They are then fired twice with the regulated charge, with one shot and two high junk wads, and examined with a searcher after each round.

In this examination they must not have any hole or cavity in the bore of ·2 of an inch in depth, behind the first re-inforce ring, or ·25 of an inch in depth before this ring.

Brass Guns.

The diameter of the bore must not vary more than ·025 of an inch from the true calibre; and the other

dimensions, in no case, more than ·2 of an inch. These guns are fired with the regulated charge as follows :—

12-pounder .... 9 ditto .... 6 ditto, heavy	twice.
6-pounder, light.... 5 ditto	three times.

Any hole or cavity ·15 of an inch in depth, upwards or side-ways in the bore, or ·1 of an inch in the bottom, between the breech and first re-inforce ring; or ·2 of an inch upwards or side-ways, or ·15 of an inch in the bottom of the bore, before the first re-inforce ring will be sufficient to condemn them.

Mortars and Howitzers.

The exterior dimensions are in no respect to deviate more than ·1 of an inch in the 10 and 8-inch howitzers, and ·05 of an inch in the 24 and 12-pounder howitzers, and Royal and Cœhorn mortars and howitzers. Their bores and chambers must not deviate from their true diameters or positions more than ·025 of an inch.

The brass mortars and howitzers are fired twice with their chambers full of powder, and an iron shell. The mortars on their own beds, at an elevation of about 75 degrees; and the howitzers, on their carriages, at an elevation of about 12 degrees. The iron mortars are

proved with a charge equal to the full chamber, and an iron shot equal in diameter to the shell.

Royal or Cœhorn mortars, having a hole of ·1 of an inch in depth in the chamber, or ·15 of an inch in the chace, are rejected; as also 24 and 12-pounder, or Royal howitzers. A hole ·15 of an inch in depth in the chamber, or ·2 of an inch in the chace, are sufficient to condemn the 10 and 8-inch howitzers.

Carronades.

The bores and chambers of carronades must not deviate more than ·05 of an inch from their true dimensions and positions. They are proved with two rounds, with their chambers full of powder, and one shot and wad.

A hole of ·2 of an inch in depth in the bore, or of ·1 of an inch in the chamber, condemns the piece.

All ordnance, after having undergone these proofs, and the subsequent searchings, are subjected to the water proof. This is done by means of a forcing pump, having a pipe or hose fitted and secured to the mouth of the piece, and a plug to stop up the vent. After two or three efforts to force the water through any honey-combs or flaws which there may be in the bore, they are left to dry, and generally the next day examined by light reflected from a mirror. If the bore should contain any small holes or flaws which have not been discovered by the former proofs, they

are very readily found by this, as the water will continue to weep or run from the holes, after the solid parts of the bore are perfectly dry.

When ordnance is suspected to be of bad quality, it is often subjected to a more rigorous proof,—that of firing twenty rounds rapidly with a charge of powder equal to the shot's weight and two shot; and in doubtful cases, where the purity of the metal is suspected, recourse has been had to chemical trials and analysis. A quantity of clean filings, taken from a part of an iron gun free from rust, are dissolved in diluted sulphuric acid, and the quantity of gas disengaged during the solution accurately ascertained. The plumbago which remains after solution is also separated by filtration, and carefully weighed. Now it is a well known fact that the purer the iron, the greater is the quantity of inflammable gas obtained, and the less is the proportion of plumbago which remains after the solution. From these two parts, therefore, a tolerable judgment may be formed of the quality of the metal. When the plumbago exceeds four and a half per cent., the iron will always be found deficient in strength; and there has been no instance of a gun bursting where the plumbago did not exceed three per cent.; that is, where one hundred grains of the metal did not leave more than three grains of plumbago. The colour of the plumbago is also to be attended to; when it is brown or reddish, it is an indication of hard metal; and when

in quantities, and mixed with foreign substances, there can be no doubt but that the iron is too soft.

When ordnance is condemned as unserviceable for any of the foregoing reasons, it is marked as follows:—*D* × for faulty in their dimensions, *S* × by searcher, and *W* × by water proof.

PROOF OF SHELLS.

After the shells have been examined as to their exterior dimensions, they are hammered all over to knock off the scales and discover flaws. They are then scraped to loosen all the sand that may be remaining from the core, and a strong puff of wind from a pair of bellows is blown into them, by which means the dust is forced out at the fuze-hole.

They are next examined by means of instruments to ascertain that they are concentric, and an empty fuze is driven into the fuze-hole, and the shell is suspended in a tub of water in such a manner that the shell is covered by the water, but that it does not run in at the fuze. In this situation the nose of a pair of bellows is inserted into the empty fuze, and a strong current of air forced into the shell; if no bubbles rise in the water, the shell is concluded to be sound and serviceable.

When shells are condemned as unserviceable, the reasons for condemning them are marked thus:—*F* for fuze-hole faulty, *N* × for non-concentric, and *W* × for water proof.

QUOINS.

Weight and Dimensions of Quoins for Land and Sea Service Ordnance.

Nature of Quoins.	Land Service. Length.				Sea Service. Length.			
	Length.	Width.	Thickness.	Weight.	Length.	Width.	Thickness.	Weight.
	Ft. In.	In.	In.	lbs. oz.	Ft. In.	In.	In.	lbs. oz.
42-Pounder	2 3	10·75	6·75		2 2	10·0	7·0	
32 Ditto 9 feet 6 inches					2 2	10·0	7·0	
32 Ditto 8 do. 0 do.	2 3	10·75	6·75		2 0·5	9·0	6·5	
24 Ditto 9 feet 6 inches	2 ·75	9·5	6·75		2 0·5	9·0	6·0	
24 Ditto 9 do. 0 do.					2 0·5	9·0	6·0	
24 Ditto 7 do. 6 do.					2 0·5	9·0	7·0	
24 Ditto 6, or 6 feet 6 inches					2 1·0	7·5	5·5	
18 Ditto 9 feet 0 inches	2 ·75	9·25	6·75		2 0·5	8·0	5·0	
18 Ditto 8 do. 0 do.					2 0	8·5	5·5	
18 Ditto 6 do. 0 do.					1 9·5	8·5	5·0	
12 Ditto 9 feet 0 inches	1 11	9·25	6·25		1 9·5	8·5	5·5	
12 Ditto 8 do. 6 do.					1 9·5	6·75	5·0	
12 Ditto 7 do. 6 do.					1 9·5	6·5	4·25	
9 Ditto 9 feet 0 inches	1 10	9·75	6·0		1 8·0	6·5	5·0	
9 Ditto 8 do. 6 do.					1 8·5	6·5	4·25	
9 Ditto 7 do. 6 do.					1 8·5	6·75	4·25	
9 Ditto 7 do. 0 do.					1 8·5	6·75	4·25	
6 Ditto 8 feet 0 inches	1 8	9·25	5·75		1 5·0	7·0	4·75	
6 Ditto 7 do. 6 do.					1 5·0	7·0	4·75	
6 Ditto 7 do. 0 do.					1 5·0	6·75	4·75	
6 Ditto 6 do. 0 do.					1 4·0	5·25	4·0	
4 Ditto	1 6	8·25	6·0		1 4·0	6·0	3·25	
3 Ditto	1 6	8·25	6·0		1 3·0	5·25	3·25	

RECONNOITERING.

In reconnoitering, every exertion should be made to acquire a familiar knowledge of the country which is the theatre of the operations of the army; and all observation should be expressed in written remarks, and by sketches on a scale sufficiently large to exhibit its minutest features. This knowledge supposes, not only an acquaintance with its natural and political divisions, and principal features, but likewise detached local information on the following points.

1. *On the Peculiar Nature of each District, and its Productions.*

What parts of it are mountainous, or hilly, and what level. If the hills are steep, broken by rocks, or rise by gradual and easy slopes; or whether the ground is undulated in gentle swells. Whether the connection of the high ground is obvious and continued, or if the heights appear detached from each other. In what directions the ridges run, and which is their steepest side. The nature and extent of the valleys; and in like manner of the ravines; where they originate, in what direction they run, and whether they are of difficult access, or to be easily passed.

Whether the country is barren or cultivated, and the kind of cultivation; vines, olives, or corn, and, if the latter, what descriptions of it are growing, and in what parts it is most abundant. If it be a country of

pasturage, whether it is pastured by cattle, sheep, or horses, and in what numbers. What parts of the country are open, and what enclosed, and the description of the enclosures;--whether small or extensive, formed by stone walls, ditches, hedges, or fences of any other kind. What parts are wooded, and whether with grown timber, or coppice wood, and with what species of trees. The nature of the soil, and of the country, generally, with reference to the operations of the troops; distinguishing those parts which are favourable for the acting of cavalry, and artillery, from those for infantry only.

2. *On the Rivers, Streams, and Canals.*

The sources of rivers, and the directions of their courses; whether they are rapid, or otherwise; their breadth and depth, and to what variations they are subject at the different seasons of the year; the nature of their channels and banks; whether rocky, gravelly, sandy, or muddy, of easy or difficult access.

The bridges across them, whether of stone or wood; their length and breadth, and whether accessible to artillery, and capable of supporting its weight.

The fords, with similar remarks, and whether they are always passable, or at certain times and seasons only. What rivers are navigable, from and to what points, and by what description of vessels or boats.

The breadth and nature of the ferries, and their landing places on each side; what description of boats

are used upon them; how many men, horses and carriages each boat is capable of conveying at each crossing; what time the passage requires, and in what manner it is performed.

The course, breadth, and depth of canals; the nature of the traffic carried on upon them; the number of boats usually to be found at different places, and their nature, dimensions, and buoyancy; also, whether they are tracked by men or horses, or how otherwise navigated.

The situation, extent and boundaries of lakes or inlets of the sea; what description of vessels can navigate them, &c., together with such of the above observations as are applicable to them.

The situation, extent, &c. of marshes; whether passable for troops in any part, and whether they continue throughout the year, or exist only in the wet season.

3. *On the Population, Resources, Accommodation for Troops, &c.*

The size of the towns and villages, and the number of their inhabitants; whether they are well supplied with provisions or not. The number of houses, churches, convents, or other public buildings. Whether the houses are commodious, or small and mean. What number of troops could be accommodated in private houses, and what, in the public buildings.

What stabling there is, or other covering for horses. Whether the town is walled or open; and favourably situated for defence, or otherwise. If it is capable of being strengthened, and by what means; with similar observations in regard to convents, gentlemen's seats, farms, or other detached buildings.

Plans or sketches of walled towns, defensible villages, or detached buildings, should always accompany the reports upon them. The number of carriages, horses, mules, and draught oxen in the possession of each farm or village, should be stated, together with the general means of conveyance made use of in the country. Whether the place is unhealthy, or not; if it is, whether there is any obvious local cause; whether it is in general unhealthy, or only so at particular seasons.

4 *On the Roads.*

Particular information must be obtained respecting the roads, in the description of which, it is impossible to be too minute.

The general nature of each road, as also all the variations which occur in it from distance to distance, should be accurately described. Whether the road has been regularly made, or appears to have been formed only by the use of the people of the country. Whether it is fit for artillery, or practicable for any description of wheel carriages, for cavalry, or for infantry only; over what description of soil it passes,

whether rocky, gravelly, sandy, clayey, or earthy, and to what injuries it is liable in bad weather, whether it is easily repairable, or not, and what materials are required for that purpose. Whether bad parts of the road, or narrow and embarrassed streets, if any, of the towns or villages through which it passes can be avoided by going out of it for a short distance; as also if any great improvement can be made in its general direction, by adopting a new line altogether for a considerable distance, and what work is necessary in either of these cases. Particular attention should be paid to the different ascents and descents of the road, whether they are gradual and easy, or abrupt, rugged and stoney, having short turns or other difficulties. Whether the road is wide enough in those parts which run along the sides of hills, and whether it is even or canted off the level so as to be unsafe for carriages.

In those parts where the road passes between walls, or where it forms a hollow way between banks of earth, rocks, or other obstacles, its breadth ought to be measured, and it should be stated whether it can be widened, or the obstacles removed which confine it.

The ferries, bridges, fords, &c. met with upon the road, should be particularly described. The possibility of obstructing, or breaking up the road so as to prevent its being used by the enemy, or of destroying the bridges and fords upon it should also be stated, and the means of effecting these objects should be pointed

out, as likewise the time and labour requisite for such a work.

The distances of the places along the road should be given, both in the measures of the country, and in English miles, averaged as accurately as possible. The time required to travel the different distances—at the ordinary walk of a horse or of a man—should also be stated, the places to the right and left near the roads, and at what points the communications strike off. Care must be taken that the names of towns, villages, rivers, &c. be spelt in the same manner as by the natives of the country, and when the spelling and pronunciation differ very much, the name should also be written (in a parenthesis) as it is pronounced.

5. *On Camps and Positions.*

All strong passes, posts, or more extensive positions, which present themselves either upon the line of road, or in any other situation, as also all passes favourable for encamping or bivouacing troops, either with the view to a position, or to convenience upon a march, should be particularly described. Their situation, extent, facility of access, nature of soil, supply of water at all seasons, quantity and kinds of wood, whether in sufficient abundance for hutting the troops, or only for furnishing fuel. A sketch of the ground upon a pretty large scale, should always accompany these reports.

Sketches of positions should never be made on a

smaller scale than four inches to an English mile; more general sketches may be made upon a scale of two inches to a mile; and tracings of roads upon a scale of one inch to a mile.

Advantage should be taken of every opportunity that presents itself, to verify and extend all such information as may be obtained upon the points above-mentioned, and whatever new information may be acquired should, without loss of time, be reduced to writing, and put into such a shape that it may be ready the instant it is called for.

In all reports, care should be taken to state distinctly what parts of the information they contain has been acquired by personal examination of the objects to which they relate, and what upon the authority of others. In the latter case the source of the information should be mentioned, that an opinion may be formed of the degree of credit to which it is entitled.

RESINS

Are of the nature of the essential oils. They usually flow from wounds made in the trunks of trees for that purpose. Almost all the concrete juices distinguished by the name of resins, are soluble in ardent spirits; water dissolves none of them. They are inflammable, and burn with much smoke. Inclosed in vessels they do not rise wholly by heat like the essential oils, but are decomposed.

The common resin of the pine, the resin of the fir, pitch, tar, and turpentine, are soluble in spirits of wine, and are of the nature of essential oils.

REVÊTEMENTS (Strength of).

The manner of determining the strength of revêtement walls is founded on the supposition that the horizontal pressure of the supported earth may overturn the wall upon the foot of its exterior face as a joint, or that it may cause the whole wall to slide off horizontally at the foundations. In the first case, the weight of the pier is supposed to act in a vertical line through its centre of gravity, and a horizontal line intercepted between this line and the foot of the exterior face, is the length of the lever at the extremity of which it acts. The product, therefore, of the weight of the revêtement (expressed by the area of a vertical section), and the length of the said lever is in that case equal to the stability of the revêtement. In the other case, the friction of the revêtement, expressed by one quarter of its weight, is equal to the stability.

The quantity of earth which is supported by the revêtement is estimated by drawing a line through the foot of the interior face of the wall, to make an angle of 45 degrees with the horizon. All the earth above this line is supposed to press against the revêtement, and to act at its centre of gravity in a direction parallel to that line; and by the resolution of forces

the horizontal pressure is found, which in this case will be equal to its weight, and is to be expressed by the area of the vertical section. The vertical distance between the centre of gravity and the foot of the revêtement is the length of lever, at the extremity of which it acts to overturn the wall. Therefore, the product of the area of the section of the earth to be supported into the length of the said lever, expresses the tendency of the earth to overturn the wall; but the tendency of the earth to push the wall forward horizontally, is only equal to the horizontal pressure before found. Therefore, equations being formed between the pressures of the earth and the stability of the wall, the unknown quantity, which is the thickness of the wall, may be found.

Colonel Pasley, of the Royal Engineers, proposes that a line should be drawn at an angle of 45 degrees with the horizon; and passing through the foot of the exterior face of the revêtement, and that only the earth contained between this line and the back of the revêtement should be considered as tending to overturn the revêtement about the foot of its exterior face as a joint, while the earth contained between the back of the revêtement and the two lines drawn through the foot of the exterior and interior faces at angles of 45 degrees with the horizon, should be considered as tending to make the revêtement wall slide forward.

From these principles Colonel Pasley arrives at the following conclusions:—

1. For full scarpe revêtements, without berms, and for demi-revêtements, having berms equal to one quarter of the height of the masonry, the mean thickness of the wall should be seventeen-sixtieths of its height, and the length of the counterforts should be one-fifth of their height.

2. For demi-revêtements, without berms, the mean thickness of the wall should be three-tenths, and the length of the counterfort should be one-fifth of the height.

3. For counterscarpe revêtements, having to retain only simple terrepleins, the mean thickness should be one-fourth, and the length of the counterfort one-sixth of the height.

In all these cases he supposes the revêtement to be countersloped, that is, to have the exterior face in a vertical plane, and the interior face inclined, so that the base of the wall is broader than the upper surface by one-fifth of its height; he also supposes the counterforts to be rectangular, and the intervals between their centres to be equal to four times their widths. Lastly, he recommends that the foundations should be deeper in rear than in front, and that the courses of masonry should form an angle with the horizon equal to about 10 degrees, except at the exterior joints, which should be made horizontal, that the rain may not penetrate. The interior face of the wall should be of an irregular form.

In order to diminish the pressure of the earth against

the revêtement, several tiers of arches may be built between the counterforts in the form of segments of circles, their extremities being worked into the masonry of the counterforts. These form what is called a counter-arched revêtement.

The tails of the counterforts are sometimes connected by arches in vertical positions, in order to increase the strength of the revêtement; the interval between the interior faces of these arches and the rear the revêtement, may be filled with rubbish.

Revêtements serving as retaining walls for wharfs and docks, are now made in the form of portions of hollow cylinders concave towards the water. The radius of curvature of the outer face is in a horizontal plane, passing through the top of the wall; and according to the present practice, the face of the wall forms an arc of a circle subtending an angle of 20½ degrees. Therefore, when the vertical height of the wall is given, the radius of curvature may be found by this proportion, viz.—As sine 20½ degrees : Radius : : height of wall : radius of curvature required. The back of the revêtement and of the counterforts may be arcs of circles concentric with the curve of the exterior face, and the joints of the masonry should be in the directions of radii from the centre of curvature.

The floors of locks and of dock basins should also be in the form of portions of cylinders similar to those of the sides, with their concave surfaces towards the water, in order to resist the hydrostatical pres-

sure arising from any water which may get behind the revêtement and under the floor, and tend to blow up the masonry when the dock is empty.

RICOCHET (Firing).

This species of firing, Durtubie observes, in his Manuel de l'Artilleur, is not confined to any particular charge or elevation; each must vary according to the distance and difference of level of the object fired at; and particularly of the spot on which it is intended the shot shall make its first bound. The smaller the angle, under which a shot is made to ricochet, the longer it will preserve its force and have effect, as it will sink, in the same proportion, so much less into the ground on which it bounds; and its tenacity will present so much the less resistance to the shot's progress. In the ricochet of a fortification of any kind, the elevation of the gun should seldom exceed 10 degrees, to throw the shot over a parapet a little higher than the level of the battery. In the field, the objects to be fired at being principally infantry and cavalry, the guns should seldom be elevated above 3 degrees; as under greater angles, the shot would be apt to bound too high, and thereby defeat its intended purpose.

The following tables of ricochet practice, shewing the charge, elevation, time of flight, and effect at various ranges with guns, howitzers, and carronades, are compiled from a series of ricochet firing carried on at Woolwich, between the 14th June and 2d October, 1821.

Nature of Ordnance.		Range. yds.	Charge. lb.	Charge. oz.	Proportion of Charge to Shell.	Elevation by Quadrant. deg.	Time of Flight. sec.	No. of Rounds fired.	No. of Shells that took effect.	Grazes made along face.	Of Rounds fired, proportion that took effect.	No. of times traverses were struck.	Remarks.
Iron Howitzers	10-Inch.	600	3		$30\frac{2}{3}$	$7\frac{1}{4}$	4	10	4	4	$\frac{2}{5}$		Work without traverses
			4		23	5	$3\frac{1}{2}$	10	2	2	$\frac{1}{5}$		
		800	3	8	$26\frac{2}{7}$	$7\frac{1}{2}$	5	10	3	3	$\frac{3}{10}$		
			4		23	$6\frac{1}{4}$	$4\frac{1}{2}$	10	1	1	$\frac{1}{10}$		
		600	2	8	$36\frac{1}{7}$	$9\frac{3}{4}$	$4\frac{1}{2}$	15	4	4		3	Work traversed
			3		$30\frac{2}{3}$	$7\frac{1}{4}$	4	15	6	4		3	
			3	8	$26\frac{2}{7}$	$6\frac{1}{2}$	$3\frac{3}{4}$	15	9	7		5	
			4		23	5	$3\frac{1}{2}$	15	5	3		4	
Iron Howitzers	8-Inch.	400	1		46	$9\frac{1}{2}$	$3\frac{1}{2}$	20	10	12	$\frac{1}{2}$		Work without traverses
			1	8	$30\frac{2}{3}$	6	$3\frac{1}{4}$	10	6	7	$\frac{1}{2}$nearly		
		600	1	8	$30\frac{2}{3}$	9	$4\frac{1}{2}$	15	4	4	$\frac{1}{4}$ do.		
			2		23	$6\frac{1}{4}$	$3\frac{3}{4}$	15	9	11	$\frac{3}{5}$		
		800	2		23	$8\frac{1}{2}$	5	15	4	5	$\frac{1}{4}$nearly		
			2	8	$18\frac{2}{5}$	$6\frac{1}{4}$	$4\frac{1}{2}$	15	7	7	$\frac{1}{2}$ do.		
		600	2		23	$6\frac{1}{4}$	$3\frac{3}{4}$	20	8	5		8	Work traversed
			2	8	$18\frac{2}{5}$	$5\frac{1}{2}$	$3\frac{1}{4}$	30	12	12		7	
Brass Howitzer	$5\frac{1}{2}$-Inch.	400		8	32	8	$3\frac{1}{2}$	15	10	13	$\frac{2}{3}$		Work without traverses
				12	$21\frac{1}{3}$	5	3	15	10	11	$\frac{2}{3}$		
		600		12	$21\frac{1}{3}$	9	$4\frac{3}{4}$	15	4	4	$\frac{1}{4}$nearly		
			1		16	$6\frac{3}{4}$	$4\frac{1}{4}$	15	3	3	$\frac{1}{5}$		
				12	$21\frac{1}{3}$	9	$4\frac{3}{4}$	15	2	4		1	Work traversed
			1		16	$6\frac{3}{4}$	$4\frac{1}{4}$	15	5	4		3	
	24-Pounder.	400		6	$42\frac{2}{3}$	$7\frac{1}{2}$	$3\frac{1}{2}$	15	8	9	$\frac{1}{2}$nearly		Work without traverses
				9	$28\frac{4}{9}$	$4\frac{3}{4}$	$2\frac{3}{4}$	15	10	16	$\frac{2}{3}$		
		600		9	$28\frac{4}{9}$	$7\frac{1}{2}$	4	15	8	8	$\frac{1}{2}$nearly		
				12	$21\frac{1}{3}$	$5\frac{1}{4}$	$3\frac{3}{4}$	15	5	7	$\frac{1}{3}$		
				9	$28\frac{4}{9}$	$7\frac{1}{2}$	4	15	3	4		3	Work traversed
				12	$21\frac{1}{3}$	$5\frac{1}{4}$	$3\frac{3}{4}$	15	4	4		1	
	12Pr.	600		6	$21\frac{1}{3}$	8	4	10	1	4			Work without traverses
				8	16	$6\frac{1}{2}$	$3\frac{3}{4}$	10	4	4			
68-Por. Carronade ..		600	1	8	$30\frac{2}{3}$	$8\frac{1}{4}$	$4\frac{1}{4}$	10	6	6	$\frac{1}{2}$nearly		

Practice with Round Shot.

NATURE OF ORDNANCE.	Range. (yds.)	Charge. (lb.)	Charge. (oz.)	Proportion of Charge to Shot.	Elev. by Quadrant (deg.)	No. of Rounds fired.	No. of Shot took effect	Grazes made along face.	Of Rounds fired, proportion that took effect.	No. of times traverses were struck.	Remarks.
Iron Ordnance, 24-Pounder, 9 feet.	400		8	48	11	15	10	13	$\frac{2}{3}$		Work without traverses.
			10	$38\frac{1}{2}$	$7\frac{3}{4}$	15	9	10	$\frac{2}{3}$ nearly		
			12	32	$6\frac{1}{4}$	30	18	26	$\frac{2}{3}$ do.		
	600		12	32	$9\frac{1}{2}$	30	15	19	$\frac{1}{2}$		
		1		24	$6\frac{1}{2}$	30	17	19	$\frac{1}{2}$ nearly		
		1	4	$19\frac{1}{5}$	$4\frac{3}{4}$	10	6	7	$\frac{1}{2}$ do.		
	800	1		24	$8\frac{1}{2}$	30	10	11	$\frac{1}{3}$		
		1	4	$19\frac{1}{5}$	$6\frac{1}{2}$	30	10	10	$\frac{1}{3}$		
		1	8	16	$5\frac{1}{2}$	15	9	11	$\frac{2}{3}$ nearly		
		2		12	$3\frac{3}{4}$	15	6	8	$\frac{2}{5}$		
	600		12	32	$9\frac{1}{2}$	20	7	5		3	Work traversed.
		1		24	$6\frac{1}{2}$	30	11	7		6	
Iron Ordnance, 18-Por. 8 feet.	400		9	32	$6\frac{1}{2}$	30	23	27	$\frac{2}{3}$ nearly		Work without traverses.
	600		12	24	$7\frac{1}{4}$	30	8	11	$\frac{1}{4}$ do.		
		1		18	5	30	10	13	$\frac{1}{3}$		
	800	1		18	7	30	10	10	$\frac{1}{3}$		
		1	8	12	$4\frac{1}{4}$	30	12	13	$\frac{1}{3}$ nearly		
	600		12	24	$7\frac{1}{4}$	30	9	8		5	Work traversed.
		1		18	5	30	13	9		9	
Iron Ordnance, 12-Pounder, 8 ft. 6 in.	400		6	32	$6\frac{1}{2}$	30	16	19	$\frac{1}{2}$ nearly		Work without traverses.
			8	24	$4\frac{1}{2}$	30	20	21	$\frac{2}{3}$		
	600		8	24	$7\frac{3}{4}$	30	11	12	$\frac{1}{3}$ nearly		
			10	$19\frac{1}{5}$	6	30	12	15	$\frac{1}{3}$ do.		
			12	16	$4\frac{3}{4}$	5	2	2	$\frac{2}{3}$		
	800		12	16	$6\frac{1}{2}$	30	7	10	$\frac{1}{4}$ nearly		
		1		12	$4\frac{1}{2}$	30	15	16	$\frac{1}{2}$		
	600		8	24	$7\frac{3}{4}$	15	7	3		6	Work traversed.
			10	$19\frac{1}{5}$	6	15	6	2		5	
9-Pounder, Brass.	600		5	$28\frac{4}{5}$	$9\frac{1}{2}$	10	0	2			Work without traverses.
			6	24	$7\frac{1}{2}$	10	1	1			
			7	$20\frac{4}{7}$	$6\frac{1}{2}$	10	3	3			
Brass Howitzers. 24-Pr.			12	32	$6\frac{1}{2}$	25	15	16			
		1		24	$4\frac{3}{4}$	10	2	12			
Brass Howitzers. 12-Pr...			10	$19\frac{1}{5}$	$5\frac{3}{4}$	10	3	3			
68-Por. Carronades ..	600	2		34	$6\frac{1}{4}$	10	4	5			

REMARKS ON THE ABOVE TABLES.

1. The work was nearly on a level with the battery.

2. At a range of 400 yards, with a charge of powder equal to $\frac{1}{32}$ of the weight of the shot, about $\frac{2}{3}$ of the rounds took effect; at 600 yards with charges from $\frac{1}{32}$ to $\frac{1}{20}$, from $\frac{1}{2}$ to $\frac{1}{3}$ took effect; and at 800 yards, with charges from $\frac{1}{24}$ to $\frac{1}{12}$, from $\frac{1}{3}$ to $\frac{2}{3}$ took effect.

3. Ricochet batteries therefore should, if possible, be at a distance of 400, and not exceeding 600 yards; as from the uncertainty of firing at a greater distance, at least two-thirds of the ammunition would be thrown away.

4. It would appear, from the whole course of the practice, both with shot and shells, that the best elevation to enfilade a work is from 6 to 9 degrees, measured above the crest of the parapet, and the charge should be regulated accordingly.

5. Of 170 shells, filled with powder, that were fired at the work when traversed, 58 took effect; but only 33 of that number burst in the work. Nevertheless, the effect on the traverses was considerable, and they were much ruined. The reason of so few of the shells bursting in the work, was in consequence of the fuzes having, in general, been cut longer than was necessary for the range, in order that time might be given for their lodging in the traverses before exploding, and this practice, therefore, is not recommended.

6. The times of flight are the averages of the most advantageous rounds.

ROCKETS.

The heights to which signal rockets ascend, and the distance at which they are visible in a level country, varies in the direct ratio of their diameters. According to Robins, rockets of between three and four inches in diameter, have been observed to ascend to the height of from 1000 to 1200 yards, while those from one to two inches in diameter only ascended from 450 to 600 yards. From some experiments which he made, " the better to determine the extent of country through which they could be seen," he found the distance to vary from thirty-five to forty miles, and their times of ascent from seven to ten seconds.

GENERAL TABLE OF SIGNAL ROCKETS.

DIMENSIONS.	Nature of Rockets.		
	2 Pound.	1 Pound.	½ Pound.
	Inches.	Inches.	Inches.
Cases .. Exterior diameter	2·13	1·69	1·34
Cases .. Interior do...	1·529	1·214	·961
Cases .. Length.........	15·97	12·67	10·05
Length of Gauge for the Choke	1·5	1·25	1·0
Heading. Cylinders Diameter..	2·84	2·25	1·79
Heading. Cylinders Length....	4·26	3·38	2·68
Heading. Cones... Diameter..	2·84	2·25	1·79
Heading. Cones... Length....	4·26	3·38	2·68

The following, when it is good and strong, is the breadth and nearly the quantity of paper required for each nature of rocket case :—

2-pounder,	breadth	20 inches.
1 ditto	ditto	15 ditto.
½ ditto	ditto	12 ditto.

It must here be understood, that the breadth of paper cut out forms, when rolled up, the length of the case ;—allowing only for cutting off to make the ends smooth.

2-pounders take about 4 sheets of 12-pounder cartridge paper.

1-pounders, 2½ sheets ; and,

½-pounders, 1 sheet of 9-pounder paper.

The paper, or rather the outermost sheet, is cut in the form of a right-angled trapezoid; the base of the slope part being always equal to the length of the exterior circumference of the case. Thus supposing the exterior diameter of a 2-pounder case to be 2·13 inches.

Then, as 7 : 22 : : 2·13 : 6·69 inches. The breadth of the slope.

Copper Ladles for Filling Signal Rockets.

Length, one and a half exterior diameter of the case.

Diameter, equal to the interior diameter of the case.

Circumference, two-thirds of the interior circumference of the case.

Composition.

	lbs.	ozs.	
Saltpetre	4	4	For Driving.
Sulphur	0	12	
Charcoal	2	0	

	lbs.	ozs.	drs.	
Saltpetre	8	0	0	For the Stars.
Sulphur	2	0	0	
Antimony	2	0	0	
Mealed powder	0	8	0	
Isinglass	0	3	12	
Spirits of wine	1 pint.			
Vinegar	1 quart.			

The driving composition is mixed, first—by rubbing the saltpetre and charcoal together between the hands for about 10 minutes, and then spreading them on the mixing table and sifting the sulphur over it; after which, it is again rubbed between the hands for a few minutes, and then passed four times through a fine hair sieve. To mix the above proportion, requires about three-quarters of an hour.

In mixing the star composition, the isinglass is first to be dissolved in the vinegar by simmering it over a clear fire, and the spirits of wine added when it is perfectly dissolved. The other ingredients are treated in the same manner as the driving composition, and then added by degrees till the whole is brought to the consistency of a stiff paste.

Table for Driving Signal Rockets. Dimensions of Drifts, Spindle, &c.

NATURE OF ROCKETS.	Brass Drifts.					Spindle.			Nature of Mallets.	Nature of Copper Ladles.	Number of Blows.
	Diameter.	Length.				Length.	Diameter.				
		First Hollow.	Second Hollow.	Third Hollow.	Solid.		Top.	Bottom.			
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	In.	In.	lbs. oz.	drs.	No.
2-Pounder......	1·529								7 4		31
1 Ditto........	1·214	12·9	10·0	7.4	6·8	6·4	·2	·5	3 8	5	25
½ Ditto........	·961	5.9			4·0	5·2	·2	·4	2 1	4	21

The rockets are driven with composition, upon the spindle, up to $3\frac{1}{2}$ exterior diameters; 1 diameter solid; and $\frac{1}{5}$ of a diameter above the composition with good dry clay.

The following table contains the dimensions and poize of the sticks. The principal point to be attended to in tying on the rockets is, that the line be not drawn so tight at the choke, where the composition is hollow, as at the head, where it is solid, for fear of injuring it.

Dimensions and Poize of Rocket Sticks.

NATURE OF ROCKETS.	Length of Sticks.		Top. Thickness.	Top. Breadth.	Square at Bottom	Distance of the Poize from the Vertex of the Cone.	
	Ft.	In.	Inches.	Inches.	Inches.	Feet.	Inches
2-Pounder ..	10	4	1·125	1·0	·525	2	9
1 Ditto....	8	2	·725	·8	·375	2	1
½ Ditto....	6	6	·5	·7	·25	1	10·5

The above table contains the dimensions and poize of the sticks, according to the present practice; it may not be amiss, however, to add the following general rules.

The stick for rockets of from half an ounce to one pound weight, must be sixty diameters of the rocket in length; and for rockets of from one pound and upwards, from fifty to fifty-two diameters. The thickness of the stick at top should be about half a dia-

meter, the breadth rather more, and the square at the bottom equal to half the thickness at top.

The following Proportions of Materials are required for making One Hundred of each Natures of Rockets.

DESCRIPTION OF MATERIALS.	Nature of Rockets. 2 Pound	1 Pound	$\frac{1}{2}$ Pound
Saltpetre pulverized.....lbs. oz...	160 0	50 0	30 0
Sulphur sublimed .... do..	39 0	12 4	7 8
Antimony .... do..	21 0	4 4	3 0
Charcoal, ground .... do..	24 0	12 0	6 12
Flour..................... do..	3 8	3 0	2 0
Glue...................... do..	0 8	0 $0\frac{1}{4}$	0 $0\frac{1}{4}$
Isinglass .... lbs. oz. drs..	2 6 8	0 7 14	0 5 4
Line, quilting. 6-Pounder..lbs. oz.	2 0		
Line, quilting. 3 ditto...... do..		1 0	0 7
Thread...... Pack .... do..	4 0	1 12	1 4
Thread...... Dutch ...... do..			0 1
Twine, packing .... do..	0 4		
Powder, mealed............ do .	17 8	2 10	1 12
Spirits of wine ......galls. qrts. pts	1 2 0	0 1 $0\frac{3}{4}$	0 0 $1\frac{3}{4}$
Vinegar........... do.	2 3 0	0 2 $0\frac{1}{2}$	0 1 1
Paper, quires, sheets Rocket.....	12 12	6 0	3 8
Paper, quires, sheets Portfire	1 20	0 9	0 4
Paper, quires, sheets White, fine .	0 12	0 5	0 5
Paper, quires, sheets Light blue ..	0 4	0 2	0 2
Paper, quires, sheets Brown		0 3	0 3
Copperas, white...... lbs. oz. drs.	0 1 0	0 0 8	0 0 8
Oil, Linseed, raw.......... pints	3	$1\frac{1}{2}$	$1\frac{1}{2}$
Paint, lbs.oz.drs Dry Prussian blue	0 0 2	0 0 2	0 0 2
Paint, lbs.oz.drs White Gen. lead ground in oil..	7 0 0	3 0 0	3 0 0
Alder .. cubic feet...............	1	$\frac{1}{2}$	$\frac{1}{4}$

SALTPETRE.

Saltpetre, or nitre, is a combination of *nitrous acid with a fixed alkali*, and is extracted principally from animal and vegetable substances, found in a putrescent state, mixed with stones, earth, &c. It is separated from the heterogeneous matter, by boiling it in water impregnated with a fixed alkali. The salt crystallizes in long filaments. This is the only method of purifying nitre; and it must be repeated two or three times, according to the quantity of the heterogeneous matter it contains. When, by this process, the nitre has been thoroughly purified, its properties are always the same, from whatever substances it may have been originally procured.

Nitre is more fully dissolved in boiling than in cold water, and a greater degree of heat is required to liquefy it than to liquefy sulphur. If the heat be increased while the nitre is in fusion, it sublimes in visible particles; which, collecting together on the upper part of the vessel, are called *flowers of nitre*. To separate the acid from the alkali, without putting the nitre in contact with a combustible body, it is necessary to expose it for a considerable time to a very strong heat; and even then the decomposition is brought about very slowly.

If a combustible body, containing a sufficient degree of heat, touch saltpetre, a very fierce flame is excited at the point of contact, accompanied with detonation, and the air becomes agitated, which increases the

activity of the fire. In this operation the acid is separated from the alkali, and dissipated. The combustible body is instantly consumed, and the alkaline residuum is termed decomposed or fixed nitre.

The decomposition takes place equally in the open air and in vacuo; provided that, in vacuo, the action of the fire be sufficient to keep the combustible body in a state of ignition.

See the word GUNPOWDER.

SAND-BAGS

Are made up in bales or packages, containing each 200 bags. Weight of each package, 1 cwt. 10 lbs.

Dimensions of Sand Bags.

	Empty.	Filled.
Length......	2 feet 8 inches.	2 feet 3 inches.
Breadth	1 do. 2 do.	1 do. 0 do.
Thickness...............		0 do. 7 do.

SAP.

The sap is a mode of carrying on the approaches at a siege, under cover, and is employed, in the more advanced parts of the attack, to protect the workmen from the fire of the place, which, in proportion as they advance, becomes too destructive to permit the approaches to be carried on by any other means. The employment of the sap generally commences about the second parallel, but sometimes sooner. If

the enfilading and other batteries, established in advance of the first parallel, have succeeded in their object of compelling the besieged to slacken their fire, it may be carried on day and night.

The sappers are usually divided into *brigades of eight men each*, and these brigades are again subdivided into *squads of four men each*, being the greatest number that can work at the sap at the same time.

In carrying on the work, the leading sapper excavates a portion of the intended trench, 18 inches in width, and the same in depth; the second, third, and fourth sappers then deepen and widen this trench, each in succession, six inches; so that the four make a trench 3 feet wide and 3 deep. Or thus. After the first sapper has excavated a space 18 inches in width and the same in depth, the second increases the depth by 18 inches, and the third and fourth each increase the breadth 9 inches. By this method, which is practised in the British service, a more speedy cover is obtained than by the former. After this the ordinary workmen follow, and enlarge it, till it is equal in dimensions to the other trenches. The sap may proceed, in this manner, at the rate of 80 fathoms in 24 hours.

As this work is both laborious and extremely dangerous, the squads are relieved every hour, and each sapper in his turn takes the lead. The whole brigade is relieved at the end of six hours.

See the words BATTERY and TRENCHES.

Weight and Dimensions of Shells for Guns, Howitzers, Mortars, and Carronades.

	Nature of Ordnance.	Diameter. Of Bore.	Diameter. Fuze Hole. Exterior.	Diameter. Fuze Hole. Interior.	Thickness of Metal.	Proposed Maximum.	Proposed Minimum.	Founder's Limit.	Difference between Diameter of Bore and Maximum.	Difference between Diameter of Bore and Medium.	Difference between Diameter of Bore and Minimum.	Weight. cwt.	qr.	lb.	oz.
		Inches.	Inches.	I .	In.	Inches.	Inches.	In.	Inches.	Inches.	Inches.	cwt.	qr.	lb.	oz.
Guns.	10-Inch ..	10·0			1·14	9·9	9·84	·08	·1	·125	·16		2	14	
	42-Pors...	7·018	1·22	1·1		6·795	6·729	·066	·223	·256	·289			20	
	32 do...	6·41	1·22	1·1		6·207	6·147	·06	·203	·233	·263			15	4¼
	24 do...	5·823	·89	·77		5·62	5·57	·05	·203	·228	·253			11	15
	18 do...	5·292	·89	·77		5·124	5·074	·05	·168	·193	·218			9	1¼
	12 do...	4·623	·89	·77		4·476	4·432	·044	·147	·169	·191			5	15
	9 do...	4·2	·89	·77		4·1	4·06	·04	·1	·12	·14			4	10
	6 do...	3·668	·89	·77		3·568	3·532	·036	·1	·118	·136			3	2
Mortars and Howitzers.	13-Inch	13·0	1·84	1·7	2·1	12·88	12·8	·08	·12	·16	·2	1	3	4	
	10 do.	10·0	1·61	1·5	1·6	9·88	9·8	·08	·12	·16	·2		3	11	
	8 do.	8·0	1·22	1·13	1·3	8·95	7·85	·1	·05	·1	·15		1	13	3
	5½ do.	5·62	0·9	0·84	0·85	5·62	5·57	·05	·0	·025	·05			15	
	4⅖ do.	4·52	0·82	0·77	0·7	4·476	4·432	·044	·044	·066	·088			7	8
	24-Pors.	5·66	0·9	0·84	0·85	5·62	5·57	·05	·04	·065	·09			15	
	12 do.	4·52	0·82	0·77	0·7	4·476	4·432	.044	·044	·066	·088			7	8
Carronades.	68-Pors...	8·05	1·22	1·1		7·95	7·85	·1	·1	·15	·2		1	5	6¼
	42 do...	6·84	1·22	1·1		6·795	6·729	·066	·045	·078	·111			20	
	32 do ..	6·25	1·22	1·1		6·207	6·147	·06	·043	·073	·103			15	4¼
	24 do...	5·68	·89	·77		5·62	5·57	·05	·06	·085	·11			11	15
	18 do...	5·16	·89	·77		5·124	5·074	·05	·036	·061	·086			9	1¼
	12 do...	4·52	·89	·77		4·476	4·432	·044	·044	·066	·088			5	15
	9 do...	4·14	·89	·77		4·1	4·06	·04	·04	·06	·08			4	10
	6 do...	3·6	·89	·77		3·568	3·532	·036	·032	·05	·068			3	2

SHOT.

Dimensions of Round Shot for Guns, Howitzers, and Carronades.

Nature of Ordnance.		Diameter of Bore.	Maximum Existing.	Maximum Proposed.	Founder's Limit.	Difference between Diameter of Bore, and Maximum.	Medium.	Minimum.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Carronades..	68-Pounder ...	8·05	7·95	7·85	·1	·1	·15	·2
	42 ditto	6·84	6·795	6·729	·066	·045	·178	·111
	32 ditto	6·25	6·207	6·147	·06	·043	·073	·103
	24 ditto	5·68	5·639	5·584	·055	·041	·0685	·096
	18 ditto	5 18	5·124	5·075	·05	·036	·061	·086
	12 ditto	4·52	4·476	4·432	·044	·044	·066	·088
	9 ditto	4·14	4·1	4·06	·04	·04	·06	·08
	6 ditto	3·6	3·568	3.532	·036	·032	·05	·068
Guns.......	68-Pounder ...	8·05	7·95	7·85	·1	·1	·15	·2
	42 ditto	7·018	6·795	6·729	·066	·223	·256	·289
	32 ditto	6·41	6·207	6·147	·06	·263	·233	·263
	24 ditto	5·823	5·639	5·584	·055	·184	·211	·239
	18 ditto	5·292	5·124	5·074	·05	·168	·193	·218
	12 ditto	4·623	4·476	4·432	·044	·147	·169	·191
	9 ditto	4·2	4·1	4·06	·04	·1	·12	·14
	6 ditto	3·668	3·568	3·532	·036	·1	·118	·136
	4 ditto	3·204						
	3 ditto	2·913	2·833	2·803	·03	·08	·095	·11
	1 ditto		1·955	1·913				
Howitzers...	10-Inch	10·0	9·88	9·8	·08	·12	·16	·2
	8 ditto	8·0	7·95	7·85	·1	·05	·1	·15
	5½ ditto	5·62	5·62	5·57	·05		·0025	·05
	4⅖ ditto	4·52	4·476	4·432	·044	·044	·066	·088
	24-Pounder ...	5·66	5·62	5·57	·05	·021	·0485	·09
	12 ditto	4·52	4·476	4·432	·044	·044	·066	·088

OF THE WEIGHT AND DIMENSIONS OF SHOT AND SHELLS.

The weights and dimensions of shot or shells might be found by means of their specific gravities. But they may be found more readily by means of the experimented weight of a shot of a given size, from the known proportion of similar figures, viz.—as the cubes of their diameters.

1. *To find the Weight of an Iron Shot.*

An iron shot of four inches diameter weighs 9 pounds. Therefore, the weights being as the cubes of the diameters, it will be,

As the cube of 4, or 64,
Is to 9 lbs., its weight;
So is the cube of the diameter of any other ball,
To its weight.

Example. The diameter of an iron ball being 6·7 inches, required its weight?

As 64 : 9 : : 2300·763 : 42·294 lbs. The weight sought.

2. *To find the Diameter of an Iron Shot.*

Multiply the weight by $7\frac{1}{9}$, and the cube root of the product will be the diameter.

Example. Required the diameter of a 42-pounder iron ball?

Here, $\sqrt[3]{(42 \times 7\frac{1}{9})} = \sqrt[3]{298{\cdot}67} = 6{\cdot}685$ inches. The diameter sought.

3. *To find the Weight of an Iron Shell.*

Take nine sixty-fourths of the difference of the cubes of the exterior and interior diameters of the shell for its weight.

That is, from the cube of the exterior diameter take the cube of the interior diameter, multiply the remainder by 9, and divide the product by 64.

Example. Required the weight of a shell, its exterior diameter being 12·8, and interior 9·1 inches?

Here, $\frac{(2097{\cdot}152 - 753{\cdot}491) \times 9}{64} = \frac{12092{\cdot}949}{64} =$ 188·941 lbs. The weight sought.

4. *To find the Size of a Shell to Contain a Given Weight of Powder.*

Multiply the weight of the powder in pounds by 57·3, and the cube root of the product will be the interior diameter of the shell in inches.

Example. Required the interior diameter of a shell to contain 6lbs. of powder?

Here, $\sqrt[3]{(6 \times 57{\cdot}3)} = \sqrt[3]{343{\cdot}8} = 7$ inches. The interior diameter sought.

If the capacity should be required, cube the diameter thus found, and multiply it by ·5236 for the content.

5. *To find the Quantity of Powder required to fill a given Shell.*

Divide the cube of the interior diameter in inches by 57·3, and the quotient will be the powder in pounds.

Example. The interior diameter of a shell being 9·1 inches, what quantity of powder will it contain?

Here, $\frac{(9{\cdot}1)^3}{57{\cdot}3} = \frac{753{\cdot}941}{57{\cdot}3} = 13{\cdot}15$ lbs. nearly. The quantity of powder required.

OF THE PILING OF SHOT AND SHELLS.

Shot and shells are usually piled in horizontal courses, either in a pyramidal or in a wedge like form, the base being either an equilateral triangle, a square, or a rectangle. The triangular and square piles terminate each in a single ball, but the rectangular pile finishes in a row of balls.

In a triangular or square pile, the number of horizontal courses is always equal to the number of balls in one side of the bottom row; and in a rectangular pile the number of courses is equal to the number of balls in the breadth of the bottom row. Also, the number of balls in the top row of a rectangular pile is one more than the difference between the length and breadth of its base.

The contents of any given pile may be readily found by the following rules.

1. *To find the Number of Shot or Shells in a Complete Pile.*

Add the three parallel edges into one sum; then, one-third of the product of that sum, and of the number of balls in the triangular face will be the number sought.

Note 1.—The *parallel edges* in a *rectangular* pile are the two rows in length at the base and the upper ridge. In the *square* pile the same, except that the upper row here is only a single ball. In the *triangular* pile one side of the base, the single ball at the top, and that at the back, are considered the parallel edges.

Note 2.—The number of balls in the triangular face is found by multiplying half the number in the breadth at the base by the number in the breadth of the base, plus one.

Examples.

1. Required the number of balls in a rectangular pile, the length and breadth of the base being 46 and 15, respectively?

Here, $(46-15)+1=32$. The number of balls in the upper row.

And, $7\frac{1}{2}\times(15+1)=120$. The number in the triangular face.

Hence, $\frac{(46+46+32)\times 120}{3}=\frac{14880}{3}=4960$.

The number sought.

2. Required the number of balls in a triangular pile, each side of the base containing 30?

Here, $15 \times (30 + 1) = 465$. The number of balls in the triangular face.

Then, $\frac{(30 + 1 + 1) \times 465}{3} = \frac{14880}{3} = 4960$. The number sought.

3. Required the number of balls in a square pile, each side of the base containing 30 balls?

Here, the number of balls in the triangular face is the same as in the preceding example, viz.—465.

Therefore, $\frac{(30 + 30 + 1) \times 465}{3} = \frac{28365}{3} = 9455$. The number sought.

2. To find the Number in a Broken or Incomplete Pile.

Compute the number in the pile considered as complete, and also the number in the upper pile, or part wanting to complete it, and the difference between the two piles thus found will be the number in the frustum or incomplete pile.

When the number of balls in the base of any pile does not exceed twenty-one, much time and trouble will be saved by making use of the following table.

Table for computing the Content of any Pile of which the Base Line does not exceed 21 Balls.

1	2	4																				
2	5	3	10																			
3	8	14	4	20																		
4	11	20	30	5	35																	
5	14	26	40	55	6	56																
6	17	32	50	70	91	7	84															
7	20	38	60	85	112	140	8	120														
8	23	44	70	100	133	168	204	9	165													
9	26	50	80	115	154	196	240	285	10	220												
10	29	56	90	130	175	224	276	330	385	11	286											
11	32	62	100	145	196	252	312	375	440	506	12	364										
12	35	68	110	160	217	280	348	420	405	572	650	13	455									
13	38	74	120	175	238	308	384	465	550	638	728	819	14	560								
14	41	80	130	190	259	336	420	510	605	704	806	910	1015	15	680							
15	44	86	140	205	280	364	456	555	660	770	884	1001	1120	1240	16	816						
16	47	92	150	220	301	392	492	600	715	836	962	1092	1225	1360	1496	17	969					
17	50	98	160	235	322	420	528	645	770	902	1040	1183	1330	1480	1632	1785	18	1140				
18	53	104	170	250	343	448	564	690	825	968	1118	1274	1435	1690	1768	1938	2109	19	1330			
19	56	110	180	265	364	476	600	735	880	1034	1196	1365	1540	1720	1904	2091	2280	2470	20	1540		
20	59	116	190	280	385	504	636	780	935	1100	1274	1456	1645	1840	2040	2244	2451	2660	2870	21	1771	
21	62	122	200	295	408	532	672	825	990	1166	1352	1547	1750	1960	2171	2397	2622	2850	3080	3311	22	2024
C.D.	3	6	10	15	21	28	36	45	55	66	78	91	105	120	136	153	171	190	210	231	253	276

RULES FOR USING THE TABLE.

1. *For the Square Pile.*

Required the content of a square pile, the number in the base being 20?

Look for the number 20 in the first vertical column on the left hand, and also in the diagonal column, and at their angle of meeting will be found the content required, viz. 2870.

2. *For the Rectangular Pile.*

Required the content of a pile, the breadth being 12, and length 17?

Look for 17 in the vertical, and 12 in the diagonal column, and at their angle of meeting will be found 1040, the content required.

3. *For the Triangular Pile.*

The number of shot in the base row being 18, required the content?

Look for 18 in the diagonal column, and opposite to it will be found 1140, the content.

The horizontal column at the bottom of the table, marked C. D., is the graduation, or common difference, of the several piles, and the differences of its terms from the arithmetical progression 3, 4, 5, &c.

SOUND.

The movement communicated to the particles of air by the vibrations of a sonorous body, is the cause

of the sensation of sound; and it is because the particles are driven from the point of vibration in every direction, as from a centre, that the sound is perceived at once, every where within the surface of a sphere of a certain extent.

Sir Isaac Newton proves, by the analogy which the pulsations of air have with the waves produced by letting a stone fall in water, and with the vibrations of a pendulum, that an aërial pulse will be propagated forward through a space equal to the circumference of a circle, the radius of which is equal to the height of a homogeneous atmosphere, in the time that a pendulum equal in length to that radius would make one double oscillation. He supposes the height of such an atmosphere to be 29,725 feet; and, since a pendulum 39·167 inches long would make one double oscillation in two seconds, he infers, by the theory of vibrations, that a pendulum equal in length to the height of the atmosphere would make one double vibration in 190·25 seconds; during which time, from what has been said, the particles of air would be carried through 186,768 feet; and, therefore, through 979 feet in one second. And this, of course, would express the velocity of sound, if the air were perfectly elastic.

The difference between this result and the observed velocity of sound, is ascribed, by Sir Isaac Newton, to the thickness of the solid particles of air, and to the vapours which float in the atmosphere. But it is evident, that the modifications which the velocity of

sound is subject to, on account of these circumstances, must be very uncertain; therefore, in determining the distances of objects by sound, we must content ourselves with the results of experiment, till a more perfect theory is discovered.

The first experiments made for the purpose of ascertaining the velocity of sound seem to have given results which are too great; and, in proportion as more care has been taken in conducting them, the velocity has been found to be less. Mr. Roberts determined it to be at the rate of 1300 feet per second; and by M. Arago, it was found to be 1106·33 feet. The experiments made by Dr. Gregory, at Woolwich, in 1823, prove it to be still less; and the results he has obtained may perhaps be considered as approaching extremely near the truth.

That gentleman employed the fire of mortars, guns, and musquets, in all the following circumstances, viz.—when the wind was scarcely perceptible; when the velocity of the wind was from 24 to 30 feet per second, in one case towards the observer, and in another directly from the observer; again, when the muzzle of the piece was turned towards the observer, and when it was turned from the observer. The heights of the barometer, during the experiments, were from 29·64 to 29·98 inches, and the temperature, ascertained by Fahrenheit's thermometer, was from 27 to 66 degrees. Lastly, the distances from the piece to the observer varied from 13,440 feet to 2100 feet.

The results are, that at the temperature expressed

by 33 degrees, the velocity is equal to 1100 feet per second, when not affected by the wind. For every degree of the thermometer below 33 degrees, half a foot is to be deducted; and for every degree above 33 degrees, half a foot is to be added to the above number, in order to express the velocity.

When the direction of the wind coincides with that in which the sound is heard, it increases the velocity of the sound by a quantity equal to its own velocity; and when the direction of the wind is contrary to that of the sound, it diminishes the velocity of the latter by the same quantity.

No difference was observed in the velocity, whether the muzzle of the piece was directed to or from the observer; but the intensity was considerably diminished in the latter case. The velocities of direct and reflected sound were found to be both the same.

The velocity of sound is not affected by its intensity; the smallest sound moves as quickly as the loudest.

From a comparison of his own experiments with those of Mr. Goldingham at Madras, Dr. Gregory concludes, that in different climates there is a small difference in the velocity of sound.

In order to ascertain the distance of any object by the report of any fire-arm, the following rule may be given. Multiply the number of seconds which elapse between the times of seeing the flash and hearing the report, by 1100, and the product will be the distance in feet, with sufficient accuracy for ordinary purposes.

If greater accuracy be required, this rule must be modified, on account of the velocity and direction of the wind, and the state of the thermometer, as above shewn.

SOUNDING.

The operation of trying the depth of the sea and the nature of its bottom, by means of a plummet sunk from a ship. There are two plummets used for this purpose; one of which is called the *hand-lead,* weighing about 8 or 9 pounds, and the other the *deep-sea-lead,* which weighs from 25 to 30 pounds; both are shaped like a frustum of a cone or pyramid. The former is used in shallow waters, and the latter at a great distance from the shore. The lines employed for these purposes are called the *deep sea lead-line,* and the *hand lead-line.*

The *hand-lead-line,* which is generally 20 fathoms in length, is worked at every 2 or 3 fathoms, so that the depth of the water may be ascertained either in the day or night. At the depth of 2 or 3 fathoms there are marks of black leather; at 5 fathoms there is a white rag; at 7, a red rag; at 10, black leather; at 13, black leather; at 15, a white rag; and at 17, a red rag.

The *deep sea lead-line* is marked with 2 knots, at 20 fathoms; 3, at 35; 4, at 40; and so on to the end. It is also marked with a single knot in the middle of each interval, as at 25, 35 fathoms, &c.

When throwing the lead, it is well rubbed over with tallow, which causes it to retain the distinguishing marks of the bottom, as shells, ooze, gravel, &c., which naturally adhere to it.

SPIKES.

There are two descriptions of spikes in the service. The common conical spike, which serves for all natures of ordnance is 4 inches long, ·275 inches in diameter at the head, and about ·1 of an inch at the point. The spikes used for temporary purposes are of the following dimensions:—

		Length.	Diameter.
12-Pounders	Medium	5·25 inches	·19 inches.
	Light	5·0 ditto	·19 inches.
9 ditto	....	4·5 ditto	·19 inches.
6 ditto	Heavy	4·0 ditto	·19 inches.
	Light	3·0 ditto	·19 inches.
Howitzers	$5\frac{1}{2}$-Inch.... 24-Por.....	4·75 ditto	·19 inches.
	$4\frac{2}{5}$-Inch.... 12-Por.....	3·25 ditto	·19 inches.

SPIRITS OF WINE

Is a limpid colourless liquid, of an agreeable smell, and strong pungent flavour. It is extremely inflammable, and burns with a pale blue flame, which is scarcely perceptible in bright daylight.

The specific gravity varies with the purity of the spirit; the purest, obtained by rectification over muriate of lime, being ·791. As it usually occurs, it is ·820, at 60 degrees; and is seldom obtained of a lower specific gravity than ·825.

STOOL-BEDS.

Weight and Dimensions of Stool-Beds for Land and Sea Service Ordnance.

NATURE OF STOOL-BEDS.	Land Service.							Sea Service.						
	Beds.			Blocks.				Beds.			Blocks.			
	Length.	Breadth.	Thickness	Length.	Depth.	Breadth.	Weight.	Length.	Breadth.	Thickness	Length.	Depth.	Breadth.	Weight.
	Ft. In.	In.	In.	Ft. In.	In.	In.	lb.oz	Ft. In.	In.	In.	Ft. In.	In.	In.	lb.oz
42-Pounder......	2 11	11·0	4·5	1 3	9·0	4·75								
									10·0	4·25	1 4·5	7·0	4·75	
32 do { 9 ft. 6 in..	2 11	10·0	4·25	1 5	9·0	4·75		2 11						
32 do { 8 0....								2 6·5	9·75	4·0	1 3·5	5·75	4·5	
24 do { 9 6....	2 10	10·0	4·25	1 4	8·0	4·5		2 11	10·0	4·0	1 3·5	7·0	4·5	
24 do { 9 0....								2 8·5	10·0	4·0	1 3·5	7·0	4·5	
24 do { 7 6....								2 8	10·0	4·0	1 3·5	8·5	4·5	
24 do { 6, or 6 ft. 6 in								2 6	10·0	4·0	1 3·5	6·0	4·5	
18 do { 9 feet....	2 8·5	9·5	4·25	1 3	8·0	4·5		2 8·75	9·75	4·0	1 3	5·0	4·5	
18 do { 8								2 6	9·75	4·0	1 3	6·0	4·5	
18 do { 6								2 3·5	9·0	3·5	1 3	5·5	4·0	
12 do { 8 ft. 6 in..	2 8·5	9·5	4·0	1 3	8·0	4·5		2 6·5	9·0	3·5	1 2	4·75	4·0	
12 do { 9 0....								2 7·75	9·0	3·5	1 2	5·0	4·0	
12 do { 7 6....								2 4·5	9·0	3·5	1 2	4·0	4·0	
9 do { 9 0....	2 8·5	9·5	4·0	1 1	8·0	4·5		2 5·5	9·0	3·25	1 2	4·75	4·0	
9 do { 8 6....								2 4·0	9·0	3·5	1 1	4·5	4·0	
9 do { 7 6....								2 3·25	9·0	3·5	1 1	4·5	4·0	
9 do { 7 0....								2 2·5	9·0	3·5	1 1	4·5	4·0	
6 do { 8 0....	2 8	8·0	3·5	1 1	8·0	4·0		2 3	8·75	3·0	1 0	4·75	3·75	
6 do { 7 6....								2 3	8·75	3·0	1 0	4·25	3·75	
6 do { 7 0....								2 1·5	8·75	3·0	1 0	4·25	3·75	
6 do { 6 0....								1 11	8·75	3·0	1 0	4·5	3·75	
4 do...........	2 3	8·5	3·5	11	8·0	4·0		1 10	8·0	3·0	1 0	4·5	3·5	
3 do...........	2 3	8·5	3·5	11	8·0	4·0		1 7	7·5	2·75	0 11	3·75	3·0	

SULPHUR

Is a substance composed of vitriolic acid and a combustible matter. It is ranked in the class of minerals, because it is extracted from the bowels of the earth. When exposed to a moderate degree of heat, it liquefies, and sublimes in little tufts called *flowers of sulphur*. Thus it is purified from heterogeneous substances by sublimation.

The property of sulphur is to take fire, inflame, and be entirely consumed, when exposed in the open air to a stronger heat than will liquefy it. It is made use of in the composition of gunpowder, because the ignited motion is easily propagated in it.

The facility with which sulphur takes fire and burns depends on the rarefaction of the surrounding air. To burn it in an exhausted receiver, it requires a continued application of a much greater degree of heat than would inflame it in the open air. The receiver should also be of a size proportioned to the quantity of sulphur, lest the condensation of the smoke prevent its total consumption. The only method of decomposing sulphur is by burning, which destroys the combustible matter, and the vitriolic acid exhales in vapour. See the word Gunpowder.

TACKLES.

Weight, Dimensions, &c. of Tackles.

Sling Carts.	Lever-ropes, 2-inch, tarred, 4 fathoms	6½ lbs.
	Sling 5½-inch white-rope, 2½ ditto	13½
	Total weight	20

		Weight.
Gyns, (Triangle)	Triple block, 12-inch	64 lbs.
	Double ditto, ditto	54
	Rope-white, 3½ ditto, 12 fathoms	26
	Total weight	144
Devil Carriage.	Guy ropes, 2½-inch tarred, 13 fathoms	28
	Preventive-rope do. 9 ditto	10
	Breach-rope, do. 6 ditto	7
	Carriage-rope, do. 3 ditto	3½
	Total weight	48½
Luff.	Double block, 8-inch	8½
	Single ditto ditto	6½
	Rope, 2½-inch, tarred, 9 fathoms	14
	Total weight	29

TANGENT-SCALE.

The tangent of one degree to a radius of one foot, is 0·2094 inches. Therefore, if the distance in feet between the base-ring and the swell of the muzzle of any gun, also in feet, be multiplied by that number, the product will be the length of the tangent of one degree:—from which the dispart being subtracted, there will remain the length of the tangent-scale above the base-ring for one degree of elevation for that particular gun. If the scale is to be applied to the quarter-sight of the gun, of course the dispart is not to be subtracted.

The former part of this rule (which is given by the Proof Department), is only correct when the length of the tangent exceeds that of the dispart; it is evidently erroneous when the contrary is the case,

as with the medium 12-pounder, the 3-pounder, and all iron ordnance at all elevations not exceeding one degree.

It also follows, from this description, that the degrees upon the scale should be equal to the differences of the tangents of the angles of elevation. Whereas, in practice, they are made equal to each other; and hence, perhaps, in part arises the difference between the elevations as given by the tangent-scale and by the quadrant.

We are aware that the reason given for this erroneous graduation is the difficulty of getting it executed correctly, on account of the small differences between the lengths of the successive tangents within the limits of the scale. But, surely an argument of this kind should not be allowed any weight in a case of so much importance as that of determining the true elevation of a piece of ordnance by either or both of the instruments employed for that purpose.

TAR,

A kind of liquid pitch used in the composition of some sorts of fire-works. See the word Resin.

TARPAULINS

Are made of strong canvas thoroughly tarred and cut into different sizes, according to their several uses. Field guns were formerly furnished with tarpaulins;

at present, only the ammunition boxes are covered with them.

TENTS.

Weights, dimensions, &c. of tents.

Captain's Marquee.

	ft.	in.		in.	
Ridge-pole, length	6	11	diam.	$2\frac{1}{2}$	in two pieces.
Standards, each	8	2	do.	$2\frac{1}{2}$	ditto.
Door-standards..........	6	3	do.	$1\frac{1}{2}$	ditto.

Pins { Large...... 4; Small...... 96 } Mallets.... 2

Weight complete, 142 pounds.

Subaltern's Marquee.

	ft.	in.		in.	
Ridge-pole, length	6	3	diam.	$2\frac{1}{4}$	in two pieces.
Standards, each	8	0	do.	$2\frac{1}{4}$	ditto.
Door-standards	6	1	do.	$1\frac{1}{2}$	ditto.

Pins { Large...... 4; Small...... 76 } Mallets.... 2

Weight complete, 134 pounds.

Bell Tent, Circular.

	ft.	in.		in.	
Standards, length......	10	3	diam.	2	in two pieces.

Pins .... 40 .... Mallets 2

Weight complete, 53 pounds.

Horseman's Tent.

	ft.	in.		in.	
Ridge-pole, length	7	0	square	$1\frac{1}{2}$	in one piece.
Standards, each	6	10	do.	$1\frac{1}{2}$	ditto.

Pins .... 24 .... Mallets 2

Weight complete, 33 pounds.

Hospital Tent.

	ft.	in.		in.	
Ridge-pole, length....	13	4	diam.	$2\frac{1}{2}$	in two pieces.
Standards, each	13	5	do.	$2\frac{1}{2}$	ditto.
Door-standards	6	$8\frac{1}{2}$	do.	2	ditto.

Pins { Large...... 4; Small......180 } Mallets.... 2

Weight complete, 3 cwts. 1 qr. 7lbs.

Mess Tent, Circular.

	ft.	in.			in.	
Standard, length	12	6	diam.	Top....	3	in two pieces.
				Bottom	$3\frac{1}{2}$	

Pins { Large...... 4; Small...... 78 } Mallets.... 2

Weight complete, 1 cwt. 1 qr. 2 lbs.

Laboratory Tent, Circular.

	ft.	in.			in.	
Standard, length	16	3	diam.	Top	3	in two pieces.
				Bottom..	5	

Pins { Large.......... 4; Small........ 100 } Mallets 2

Weight complete, 2 cwts. 10 lbs.

TERTIATE.

To tertiate a piece of ordnance, is to examine whether it has the due thickness of metal at the vent, &c. if the trunnions are of the true dimensions and properly placed, the bore straight, &c. See the word Proof.

TIMBER.

Under the head Bridges we have given an article on the buoyancy of bodies immersed in fluids, together with the rules for computing the quantity of any given material required to float a given weight. Before these rules, however, can be applied to timber, its solid content must be found by the following rule.

To find the Content of a Tree or other piece of Timber.

Add the areas of the two ends and their geometrical mean together, then, multiply one-third of this sum by the length, and the product will be the content of the tree.

Example. The length of a tree being 30 feet, and the areas of its two ends 336·05 and 214·5 inches, required its solid content?

First, $\sqrt{(336{\cdot}05 \times 214{\cdot}5)} = 268{\cdot}2$. The geometrical mean.

Then, $\frac{336{\cdot}05 + 268{\cdot}2 + 214{\cdot}5}{3} \times 360 = 98247{\cdot}2$

cubic inches, or 56·8 cubic feet. The content sought

TOISE.

A French measure, containing six feet. The proportion of the English yard to the French demi-toise, is as 36 to 38·355.

TONNAGE.

The usual method of computing the tonnage of any vessel is by the following rule:—

Multiply the length of the keel by the breadth of the beam, and that product, again, by half the breadth of the beam. Then divide this last product by 94, and the quotient will be the tonnage.

Example. The length of a ship's keel being 72 feet, and the breadth of the beam 24 feet, required her tonnage?

Here, $\frac{72 \times 24 \times 12}{94} = 220{\cdot}6$ tons. The tonnage sought.

The tonnage of goods and stores is taken sometimes by weight, and sometimes by measurement; and that method is allowed to the vessel which yields the greatest tonnage. In tonnage by weight, 20 cwt. make 1 ton. In tonnage by measurement, 40 cubic feet are equal to 1 ton.

All carriages, or other stores to be measured for tonnage, are taken to pieces, and packed in the manner which will occupy the least room when embarked. All ordnance, whether brass or iron, ammunition in boxes, and other very heavy articles,

are taken in tonnage, according to their actual weight.

See also the words EMBARKATION and TRANSPORTS.

TRAJECTORY (of a Shot in the Atmosphere).

The efforts hitherto made to determine, by theory, the range of a shot, and the form of its trajectory in the air, may be said to have entirely failed, except when the velocity of the projectile is small, in which case, the circumstances of its motion do not differ materially from those determined by the parabolic theory. Sir Isaac Newton, who first developed the laws of motion in resisting media, shews that the path of a shot through the air must be of the hyperbolic kind, having the asymptote of the descending branch perpendicular to the horizon; and he considers that the conical hyperbola will represent the path with sufficient accuracy for practice.

From the experimented ranges of two balls of equal bulks and weights, and discharged with equal velocities, at different angles of elevation of the gun, he determines, by a tentative process, the positions of the asymptotes of either; and thence, by the general properties of the hyperbola, he constructs the curves they describe. He, also, shews how the range and curve may be found, when the velocity remains the same, and the elevation is changed; or, when the elevation is the same, and the velocity is changed; and, conse-

quently, the real trajectory may be determined for a shot discharged in any circumstances, provided we have from experiment the ranges of two shot, similar and equal to that of which the trajectory is required, and fired with different velocities from a gun, also similar and equal to that which is to be used. The experiments performed at Sutton, in 1811 and 1812, afford many data for shot and shells, by which the hyperbolic theory has been tried; and it has been found to give ranges which do not differ more from those obtained by experiment than many of these differ from each other, even when all circumstances are equal; but more such experiments will be necessary, before the hyperbolic theory can be applied to all the different kinds of shot and guns.

According to Dr. Hutton, the angle of elevation for the greatest horizontal ranges is between 30 and 45 degrees, being gradually more below 45 degrees, as the shot is smaller and the velocity greater. The ascending branch of the trajectory is less curved than the other, and the vertex of the curve is nearer to the remote extremity of the range than to the gun, and the point of greatest curvature is beyond the vertex. The ball does not ascend so high as it would if it moved in a parabola, and the horizontal velocity is continually diminishing, both in the ascending and descending branch.

Since Sir Isaac Newton's time, mathematicians have investigated, according to the received law of the

resistance of the air, formulæ for determining the ordinates of the trajectory, when the inclination of the gun and the initial and terminal velocities of the shot are given; but they are excessively complicated, and the best formulæ of this kind that have been given produce, for the results, ranges which are often greater, by one-half, than those found by experiment. The following is one of the most simple:—

$$y = \left\{ \text{tan. } E + \frac{H}{2\,h \text{ cos. } E} \right\} x - \frac{H}{2\,h} \left\{ e^{\frac{x \text{ cos. } E}{H}} - 1 \right\}$$

Where E is the elevation of the gun; $H =$ the height due to the terminal velocity; $h =$ the height due to the initial velocity; $e = 2{\cdot}71828$; $x =$ the abscissa, reckoned from the gun on a horizontal line, and $y =$ the ordinate to the curve, perpendicular to the horizon.

TRANSPORTS.

The proportion of tonnage for troops embarked in transports is two tons per man.

See the word Embarkation.

TRENCHES.

A general term for all the approaches at a siege.

The approaches are generally carried on upon the prolongations of the capitals of the works attacked, as being, of all other situations in the front of a work, the least exposed to the fire of the garrison, and at

the same time least in the line of fire between the besieged and besiegers' batteries. But if, from particular circumstances, these or other advantages do not attend the approaches upon the prolongations of the capitals, they are by no means to be preferred to more secure positions.

The zig-zags, or boyaux of communication, are generally 3 feet deep, 10 feet wide at the bottom, and 13 at the top, having a berm of one foot, beyond which the earth is thrown to form the parapet.

The parallels, or places of arms, are 3 feet deep, 12 feet wide at bottom, and 17 or 18 feet wide at top, having a banquette 3 feet broad, with a slope of nearly as much.

The first night of opening the trenches, the greatest exertions are made to take advantage of the enemy's ignorance as to the side of attack; and they are generally carried on as far in advance as the first parallel, and sometimes even to the completion of that work. Some authors, however, recommend commencing the operation with the parallel, and opening the communications to the rear, on the morning of the following day. This method of proceeding has very considerable advantages, particularly as affording cover to the guards of the trenches, and thereby enabling them more effectually to protect the work in case of a sally. The workmen set out on this duty, each provided with a fascine 6 feet long, a pick-axe, and a shovel. The fascines, when arranged on the ground, lap over

each other one foot, which leaves 5 feet of trench for each man to dig.

The usual method of directing the trenches on zig-zags, is by observing, during the day, some near object in a line with the saliant parts of the work, which may serve as a direction in the night; or, if the night be not very dark, the angles of the works may be seen above the horizon: but, as both these modes of proceeding are subject to uncertainty, the following is proposed, to answer every case. Having laid down, on the plan of attack, the exact positions of the flanked angles of the front attacked, and particularly of those most extended to the right and left, mark upon the plan the point of commencement for the first portions of zig-zag; the point where it crosses the prolongation of the capital; and the point to which it extends on the other side of the capital. This last point will be the commencement of the second branch. Then mark off the point where this branch crosses the prolongation, and its extent on the other side, and this will give the commencement of the third branch; and so on for the others. Thus provided with a directing plan ready marked off, it will be very easy, even during the darkest night, to lay down the points where the boyaux are to cross the prolongations of the capitals, and the points to which they are to be produced beyond them.

The first parallel is generally run at about 600 yards from the place, and to such extent as to embrace the prolongations of the faces of all the works which fire

upon the approaches;—and each end has a return of about 30 or 40 yards.

The second parallel is constructed upon the same principles and to the same extent as the first, at the distance of about 300 yards from the saliants of the covered-way. The parapet of this parallel is usually formed of gabions, each workman carrying a gabion, a fascine, a shovel, and a pick-axe. After this, the remainder of the approaches are carried on by sapping.

The half parallels are run at about 140 or 150 yards from the covered-way, and extend on each side sufficiently to embrace its branches.

The third parallel should be run near the foot of the glacis, otherwise it will mask the fire of the ricochet batteries. It is generally made rather wider than the other parallels.

It is sometimes necessary to construct a fourth parallel, within six or eight fathoms of the crest of the covered-way, especially when the garrison is very numerous, or when all their artillery cannot be dismounted. See also the word BATTERY.

TROUS-DE-LOUP

Are reversed frustra of cones. Diameter of the base, 4 feet 6 inches. Depth, 6 feet. Picket, 6 feet long, and from 4 to 5 inches square. Contain three quarters of a cubic fathom of earth, and are usually placed two in three fathoms.

See the word FIELD FORTIFICATION.

TRUCKS.

Weight and Dimensions of Trucks for Land and Sea Service Ordnance.

Nature of Trucks.	Fore.					Hind.				
	Diameter of Truck.	Diameter of Hole.	Thickness.	Width of Sole.	Weight.	Diameter of Truck.	Diameter of Hole.	Thickness.	Width of Sole.	Weight.
	Ft. In.	In.	Ft. In.	In.	cwt. qr. lbs	Ft. In.	In.	In.	In.	cwt. qrs. lbs
Land Service, Iron. 42-Pounders	1 7	7·5		6·625	3 0 20	1 4	7·5		5·0	2 0 4
32 do.	1 7	7·5		6·625	3 0 20	1 4	7·5		5·0	2 0 4
24 do.	1 7	6·5		5·0	2 1 26	1 4	6·5		4·5	1 2 5
18 do.	1 7·75	6·5		5·0	2 1 26	1 4	6·5		4·5	1 2 5
12 do.	1 7·75	6·5		5·0	2 1 26	1 4	6·5		4·5	1 2 5
9 do.	1 7·75	6·5		5·0	2 1 26	1 4	6·5		4·5	1 2 5
6 do.	1 6·25	5·5		4·25	1 3 4	1 4	5·5		3·5	1 1 6
4 do.	1 6·25	5·5		4·25	1 3 4	1 4	5·5		3·5	1 1 6
3 do.	1 6·25	5·5		4·25	1 3 4	1 4	5·5		3·5	1 1 6

Trucks.—Continued.

	Nature of Trucks.	Fore. Diameter of Truck	Fore. Diameter of Hole.	Fore. Thickness.	Fore. Width of Sole.	Fore. Weight.	Hind. Diameter of Truck	Hind. Diameter of Hole.	Hind. Thickness.	Hind. Width of Sole.	Hind. Weight.
		Ft. In.	In.	Ft. In.	In.	cwt.qr.lbs	Ft. In.	In.	In.	In.	cwt.qr.lbs.
Sea Service, Wood.	68-Pounder	1 7	3·68	6·0			1 5	6·38	6·0		
	32 do.	1 7	6·38	6·0			1 4	6·38	6·0		
	24 do.	1 6	6·38	5·5			1 4	6·38	5·5		
		1 6	5·88	5·0			1 3	5·88	5·0		
	18 do.	1 6	5·88	5·0			1 3	5·88	5·0		
		1 4	5·38	4·5			1 2	5·38	4·5		
	12 do.	1 4	5·38	4·5			1 2	5·38	4·5		
	9 do.	1 4	5·13	4·0			1 2	5·13	4·0		
	6 do.	1 2	4·63	3·5			1 0	4·63	3·5		
	4 do.	1 1	3·88	3·5			11	3·88	3·5		
	3 do.	1 0	3·63	3·0			1 5·0	3·63	3·0		

TUBES.

The pipes of the metallic tubes 3 inches long, and the cups, previously to being stamped, are 1 inch in diameter. The pipes for the Dutch tubes are 2 inches long, and their cups are ·4 of an inch deep. All tubes are gauged to ·2 of an inch.

Composition :—mealed powder, mixed up stiff with spirits of wine.

The following Proportions of Materials are required for making One Thousand Tubes of each Nature :—

DESCRIPTION OF MATERIALS.	Brass.	Quill. Com-mon.	Quill. Fynm-ores.	Dutch.
Brass, thin sheets . . lbs. oz.	25 0			
Solder . . . . do. .	10 0			
Rosin . . . . do. .	2 0			
Salamoniac . . . . do. .	1 0			
Charcoal, white . . . bushels	1 0			
Quills.		1000	1000	
Worsted. . . . . ozs.		4½	0 10	
Paper, Qrs. Shts. Cart. 24-Prs.	0 5		0 7	
Paper, Qrs. Shts. Cart. ½ do.				0 5
Paper, Qrs. Shts. White, fine . .	0 18	0 15	0 20	0 30
Paper, Qrs. Shts. Whited brown	0 5	0 5	0 10	
Mealed Powder, lbs. ozs. . . .	4 12	3 0	6 0	2 3
Spirits of wine. . . . . . pints	2	1	3½	1
Gum arabic.			5	
Thread, Dutch. . . . lbs. oz.				0 2
Twine, packing. . . . . . . ozs.	0 5	0 4	0 13	

The metallic tubes are preferred for land, and the quill for sea service.

TURF.

This is a very important article in the construction of batteries and field-works, and should be cut from the best meadow land, in patches 15 inches long, 12 broad, and from 5 to 6 inches thick, according to the herbage.

To find the Number of Turfs required to Rêvete a Work.

Divide the length and breadth of the slope, in inches, by the length and thickness of a turf; and the product of these two quotients will be the number required.

Example. How many turfs are required to rêvete a slope 20 feet long and 7 feet high?

Here, $\frac{20 \times 12}{15} = 16$, the number of turfs in each course.

And $\frac{7 \times 12}{6} = 14$, the number of courses.

Hence, $16 \times 14 = 224$, the number of turfs required.

Should the edges of the slopes be irregular, the mean length and breadth must be taken.

In rêveting any work, the turfs should be placed perpendicularly to the slopes, and alternately as headers and stretchers, like bricks in a wall. Care

should also be taken that their vertical joints do not fall directly over each other.

VELOCITIES (of Shot).

From the experiments made at Woolwich on the velocities of shot, the following results have been obtained:—

1. The velocities communicated to shot of the same weight, by different charges of powder, are nearly proportional to the square roots of the charges.

2. When the charges are of equal, and the shot of unequal weights, the velocities are inversely proportional to the square roots of the weights nearly.

3. When both the weights and charges are unequal the velocities are proportional to $\frac{\sqrt{\text{charges}}}{\sqrt{\text{weights}}}$, nearly.

4. When the charges of powder are equal, the velocities increase with the length of the gun, but not in so high a ratio. The same thing may be said of the maximum velocity.

5. The ranges increase in a much lower ratio than the velocities: hence little is gained in the range, by a great increase in the length of the gun. A double length of gun only increases the range about one-seventh.

6. The initial velocities increase with the charge to

a certain degree, after which they diminish till the bore is filled with powder.

To find the velocity with which a shot of a given weight will be projected from a gun, with a given charge of powder.

By experiment it has been found, that 8 oz., or 0·5 pounds of powder, will discharge a one-pound ball with a velocity of 1600 feet per second; therefore, by the third rule, $\sqrt{0.5} : 1600 :: \frac{\sqrt{\text{charge}}}{\sqrt{\text{weight}}} : 2263$ $\frac{\sqrt{\text{charge}}}{\sqrt{\text{weight}}}$, the velocity required.

To find the velocity with which an iron ball, projected horizontally in the air, moves, after having described a certain given space.

By substituting the expression for the retarding force f; viz. $\frac{m\,v^2 - n\,v}{w}\,d^2$, in the fluxional equation for motion, viz. $v\,\dot{v} = 2\,g\,f\,\dot{s}$; there arises, by integration, the equation $S = \frac{32\,m\,d^2}{w} \times \text{hyp.-log.}\ \frac{V-231}{v-231}$; where $S =$ the given space, $m = \cdot00000756$, $w =$ the weight, and $d =$ the diameter of the ball, $V =$ the given initial velocity, and $v =$ the velocity required.

From this equation, by reduction, we have $\frac{d\,s^2}{9511\cdot5\,w}$ $= \text{com. log.}\ \frac{V-231}{v-231}$, and to find v, consider the left-

hand member of the equation as a logarithm, and find, in a table, the natural number corresponding to it, which call N; then $N = \frac{V-231}{v-231}$, from which v may be found.

This last problem is useful in determining the elevation which should be given to a gun, that, when the shot is discharged with a given velocity, it may strike an object placed at a given distance from it. For which purpose, find, by this problem, the velocity of the shot after it has passed over the given space; and the mean of this, and the initial velocity, may be considered as the medium uniform velocity of the shot within that space; divide the given space, in feet, by the velocity, and it will be the time of flight in seconds; lastly, find the space through which a body will descend vertically in vacuo, during that time, by the power of gravity. If the given space be not considerable, this will give the required deflection of the shot, in feet, from the axis of the gun, when arrived at the object; from which the angle of elevation may be found trigonometrically.

VELOCITIES OF EFFLUENT FLUIDS.

If a very small orifice be made in the bottom of a vessel containing a fluid, the pressure on a particle of the fluid at the orifice is equal to the weight of a vertical filament of the fluid immediately over the particle, and this is equal to the sum of the actions of gravity upon all the particles in that filament. But if a par-

ticle fall through a height equal to that of the filament, it is acted upon at every instant of its descent by a force equal to the weight of the particle, and the sum of all those actions of gravity is equal to the weight of the filament; therefore, the velocity with which a particle will issue from the orifice, will be the same in both cases. It follows that the velocity with which the fluid issues from a very small orifice in the bottom, or in the side close to the bottom, is equal to that which a body would acquire by falling through a height equal to that of the column of fluid above the orifice.

And if orifices were made at different depths in the side of the vessel, the velocities with which the fluid issues would be proportional to the square roots of the depths of the orifices; because, the velocities which bodies acquire by gravity in falling, are proportional to the square roots of the spaces descended.

But when the orifice in the bottom or side of a vessel is large, the fluid converges towards the axis of the stream after quitting the orifice, and forms a contraction in the stream, the area of which is to the area of the orifice, as 1 to $\sqrt{2}$. Therefore, because equal quantities of fluid pass through unequal sections of the same pipe in equal times, it follows that the velocity in the contraction is to the velocity in the orifice as $\sqrt{2}$ to 1. And the velocity in the contraction is equal to that acquired by a body falling through the whole height of the fluid; therefore, the velocity in

the orifice will be equal to that acquired by falling through half the height of the fluid.

By experiment it has been found that the quantities of water discharged in equal times through orifices of different sizes, and at the same depths in the vessel, are proportional to the areas of the orifices, or to the squares of their diameters.

From the principles before stated, it may be proved that a cylindrical or prismatic vessel, if kept constantly full, will discharge through an orifice twice as much water as it contains, in the time that it would take to empty itself through the same orifice.

Also, that if a notch or sluice in the form of a rectangle be cut vertically in the side of a vessel full of water, the quantity of water flowing through it will be equal to two-thirds of the quantity which would flow in the same time through an equal orifice placed horizontally at a depth equal to that of the bottom of the vertical notch, the vessel being kept constantly filled to the level of the top of the same notch.

From the experiments of M. Bossut, it appears that when water flows through a pipe 30 feet long and 1·25 inches in diameter, the velocity at the mouth of the pipe is only half of that at the orifice; and that when the pipe is 180 feet long, and of the same diameter as before, the velocity at the mouth is only equal to one-sixth of that at the orifice, the loss of velocity being caused by the friction within the pipe.

And M. Bossut concludes that the quantities discharged through pipes of equal diameters in equal times, and with the same head in the reservoir, are inversely proportional to the square roots of the lengths of the pipes nearly.

VENT.

The vents of English ordnance are all ·2 of an inch in diameter.

In consequence of the enlargement of the vents of the iron guns employed at the sieges of Badajos and St. Sebastian in 1812 and 1813, Lord Mulgrave, then Master-General of the Ordnance, upon a representation from the Proof Office, gave orders for trials to be made with four 24-pounders, to ascertain "what number of rounds this iron ordnance was capable of sustaining without injury when the fire is incessant;" and whether or not any advantage would arise from bouching ordnance of this description with wrought iron or copper.

The guns employed were 24-pounders, of 9 feet, as follows:—

	cwts. qrs. lbs.		
Messrs. Walker's.	48 0 4	Common vents	Fired 20th, 21st, and 22d of Sept. marked in first column 1st, 2d, 3d days.
	48 2 4		
Carron Co.	48 1 12	Wrt. iron	
	48 1 18	Copper	Fired 11th, 12th, and 13th of October.

The charge was 8 lbs. of powder, with one round shot and two junk wads.

The following are the Results of these Trials.

TRIAL.	Rounds Fired.	Time. Between each Round	Time. In firing the Rounds.	Time. For examination.	Vents enlarged. Messrs. Walker's Gun. Common Vent.		Vents enlarged. Carron Co.'s Guns. Common Vent.		Carron Co.'s Guns. Wrought Iron Vent.		Carron Co.'s Guns. Copper Vent.		Thermometer. 21st, 22d, and 23d September. In the Air.	21st, 22d, and 23d September. In the Gun.	11th, 12th, and 13th October. In the Air.	11th, 12th, and 13th October. In the Gun.
Days.	N°	Min	Min.	Min.	Top.	Bot.	Top.	Bot.	Top.	Bot.	Top.	Bot.	Deg.	Deg.	Deg.	Deg.
First....	25	4	96	24	·004	·003	·003	·005	Increase hardly perceptible.		Increase not perceptible.		64	71	53	58
	25	4	96	114	·068	·003	·038	·018					67	79	53	66
	25	4	96	24	·068	·046	·043	·033					68	78	58	63
	25	4	96	end of firing.	·078	·063	·048	·038					60	71	56	64
Second..	50	3	147	24	·103	·078	·073	·05	·033	·011	ditto	ditto	68	83	56	64
	50	3	147	72	·105	·088	·078	·058	·048	·02	·003		62	92	56	72
	50	3	147	end of firing.	·113	·108	·103	·077	·058	·02	·02	·008	62	90	58	87
Third...	50	3	147	24	·163	·113	·128	·078	·088	·028	·028	·01	66	82	58	78
	50	3	147	72	·218	·178	·133	·118	·098	·03	·03	·013	66	92	56	72
	50	3	147	end of firing.	·25	·208	·178	·123	·138	·093	·033	·017	62	89	55	72

After firing 400 rounds from each of the guns with iron vents, on the 20th, 21st, and 22d September, their bores were carefully examined, and found not in the least injured, except being a little dented near the seat of the shot; and notwithstanding the vents continued to enlarge, yet that of wrought iron was in so small a degree as to afford a prospect of very considerable resistance, from which it was recommended that iron ordnance demanded for siege might be vented previously to their being issued, as also that spare vents should be sent to replace such as might be damaged by long and severe service.

But from the favourable results of the 11th, 12th, and 13th October, carried on with a gun of the same description vented with pure copper, it appears that a decided preference should be given to it, unless, for better determining the point, it might be adviseable, should battering ordnance be demanded, to send a proportion vented in each way.

WADMILTILT.

Length, 14 feet, 6 inches; breadth, 11 feet, 6 inches; weight, 50 pounds.

WEIGHTS AND MEASURES.

The following tables contain the principal weights and measures now used in this country, and their comparison with those of other countries, but more particularly with those of France.

WEIGHTS.

Troy Weight.

24 Grains make	....	1 Pennyweight.
20 Pennyweight	....	1 Ounce.
12 Ounces	....	1 Pound.

Avoirdupois Weight.

16 Drachms make	....	1 Ounce.
16 Ounces	....	1 Pound.
28 Pounds	....	1 Quarter.
4 Quarters	....	1 Hundred.
20 Hundreds	....	1 Ton.

Also, 14 pounds make 1 stone, horseman's weight, and 8 pounds 1 stone, in the London markets.

MEASURES.

Long Measure.

3	Barleycorns make	....	1 Inch.
12	Inches	....	1 Foot.
3	Feet	....	1 Yard.
2	Yards	....	1 Fathom.
$5\frac{1}{2}$	Yards, or $16\frac{1}{2}$ Feet	....	1 Pole.
40	Poles	....	1 Furlong.
8	Furlongs, or 1760 Yards	....	1 Mile.
3	Miles	....	1 League.

Also, 4 inches make 1 hand; 5 feet, 1 geometrica paces; and 4 poles, or 66 feet, or 100 links, each 7 $\frac{92}{100}$ inches, make 1 chain.

Superficial, or Square Measure.

144	Square Inches make	1 Square Foot.
9	ditto Feet....................	1 ditto Yard.
30¼	ditto Yards	1 ditto Pole.
40	ditto Poles	1 ditto Rood.
4	ditto Roods, or 160 Square Poles	1 Acre.

Solid or Cubic Measure.

1728	Cubic Inches make	1 Cubic Foot.
27	ditto Feet	1 ditto Yard.
231	ditto Inches	1 Gallon Wine Measure.
282	ditto Inches	1 ditto Beer ditto.
2150·42	ditto Inches.........	1 Bushel Dry ditto.

Dry Measure.

2 Pints make	1 Quart.
2 Quarts	1 Pottle.
2 Pottles, or 4 Quarts	1 Gallon.
2 Gallons	1 Peck.
4 Pecks....................................	1 Bushel.
8 Bushels, or 2 Cooms	1 Quarter.
5 Quarters................................	1 Wey.
2 Weys	1 Last.

Ale and Beer Measure.

2	Pints make	1 Quart.
4	Quarts	1 Gallon.

36	Gallons	1 Barrel.
1½	Barrels	1 Hogshead.
2	Barrels	1 Puncheon.
2	Hogsheads	1 Butt.
2	Butts	1 Tun.

Wine Measure.

2 Pints make	1 Quart.
4 Quarts	1 Gallon.
42 Gallons	1 Tierce.
63 Gallons	1 Hogshead.
2 Tierces	1 Puncheon.
2 Hogsheads	1 Pipe.
2 Pipes	1 Tun.

According to an Act of Parliament passed in June, 1824, and which came into operation on the 1st January, 1826, the distinction between the ale, wine, and corn gallon, is abolished, and an imperial gallon is established, as well for liquids as for dry goods not measured by heaped measure. This gallon must contain precisely "10 pounds, avoirdupois weight, of distilled water, weighed in air, at the temperature of 62 degrees of Fahrenheit's thermometer, the barometer standing at 30 inches."

By this Act also,

The pound troy contains 5760 grains.

The pound avoirdupois contains 7000 grains,

The imperial gallon contains 277·274 cubic inches, and,

The corn bushel, eight times the above.

Hence, with respect to ale, wine, and corn, it will be expedient to possess a

TABLE OF FACTORS,

For Converting Old Measures into New, and the contrary :—

DESCRIPTION OF CONVERSION.	By Decimals.			By Vulgar Fractions nearly.		
	Corn Measure.	Wine Measure.	Ale Measure.	Corn Measure.	Wine Measure.	Ale Measure.
From Old Measures to New	·96943	·83311	1·01704	$\frac{31}{32}$	$\frac{5}{6}$	$\frac{60}{59}$
From New Do. to Old	1·03153	1·20032	·98324	$\frac{32}{31}$	$\frac{6}{5}$	$\frac{59}{60}$

For reducing the prices, these numbers must all be reversed.

The two following examples will illustrate the rules :—

1. Reduce 63 gallons, wine measure, to the equivalent number in imperial measure.

Here, $63 \times \cdot 83311 = 52\cdot 486$; or, $63 \times \frac{5}{6} = \frac{315}{6}$ $52\frac{1}{2}$ imperials gallons nearly.

2. Reduce eight bushels imperial measure, to the equivalent number in Winchester measure.

Here, $8 \times 1\cdot 03153 = 8\cdot 25224$; or, $8 \times \frac{32}{31} = 8\frac{1}{4}$ Winchester bushels nearly.

COMPARISON OF THE FRENCH AND ENGLISH WEIGHTS AND MEASURES.

New Weights and Measures.

In order to express decimal proportions in their new system of weights and measures, the French have adopted the following terms:—

The term *deca*, prefixed, denotes *ten* times; *hecto*, *one hundred* times; *kilo*, *one thousand* times; and *myria*, *ten thousand* times. On the other hand, *deci* expresses the *tenth* part; *centi*, the *hundredth* part; and *milli*, the *thousandth* part.

Thus decametre signifies ten metres; and decimetre, the tenth part of a metre, &c.

Units, which form the Basis of the French System, compared with the Weights and Measures of England.

French.		English.
The Metre	=	3·2809167 feet, or 39·371 inches.
Are	=	1076·441 square feet.

French.		English.
The Litre	=	61·028 cubic inches.
Stere	=	35·317 cubic feet.
Gramme	=	15·441 grs. troy, or 5·6481 drachms avoirdupois.

New Weights and Measures of France, compared with the Old, and also with English Weights and Measures.

Linear Measure.

	French feet.	English feet.
Distance from the Equator to the Pole.	30784440	32809167
Degree (centesimal)......	...307844·4	328091·67
Myriametre	30784·44	32809·167
Kilometre................	3078·444	3280·9167
Hectometre	307·8444	328·09167
Decametre...............	30·78454	32·809167
METRE.....................	3·078444	3·2809167

	French inches.	English Inches.
Decimetre...............	3·6941	3·9371
Centimetre..............	0·3694	0·3937
Millimetre..............	0·0369	0·0394

Superficial or Square Measure.

	French square feet.	English square feet.
Miriare	9476817·46113	10764414·3932

	French square feet.	English square feet.
Kiliare....	947681·746113	1076441·43932
Hectare....	94768·1746113	107644·143932
Decare......	9476·81746113	10764·4143932
Are..	947·681746113	1076.44143932
Deciare	94·7681746113	107·644143932
Centiare.........	9·47681746113	10·7644143932.

	Square Inches.	Square Inches.
Square Decimetre........	13·646617	15·500756.

	Square Lines.	Square Lines.
Square Centimetre........	19·651134	22·321088
Square Millimetre	·19651134	·22321088

Measures of Capacity.

	French Cubic Feet.	English Cubic Feet.
Myrialitre......	291·738519	353·1714693
Kiliolitre, or Metre Cube ..	29·1738519	35·31714693
Hectolitre..........	2·91738519	3·531714693

	Cubic Inches.	Cubic Inches.
Decalitre	504·12416	610·280264
Litre, or Cubic Decimetre	50·412416	61·0280264
Decilitre	5·0412416	6·10280264

	Cubic Lines.	Cubic Lines.
Centilitre	871·126926	1054·564296

The litre, which is the unit for measures of capacity

is equal to 2·113 English pints, wine measure; and therefore the hectolitre equals 26·4 such gallons, and 35 litres equal a Winchester bushel.

Solid or Cubic Measure.

	Fr. Cubic Feet.	Eng. Cubic Feet.
Decastere	291·738519	353·17
STERE, (cubic metre)	29·1738519	35·317
Dicistere	2·91738519	3·5317

This measure is used for fire-wood, stone, &c. The STERE is the same as the kilometre in the preceding measure.

New French Measure of Time, compared with the Old, or Usual System.

New Division.	Old Value.		
	hours.	minutes.	seconds.
1 Second	0	0	0·864
100 Seconds, 1 Minute	0	1	26·4
100 Minutes, 1 Hour	2	24	0
10 Hours, 1 Day	24	0	0

Reversed.

Old or Usual Division.	New Value.		
	hours.	minutes.	seconds.
1 Second	0	0	1·1574
60 Seconds, 1 Minute	0	69	54·4
60 Minutes, 1 Hour	1	15	74·0
24 Hours, 1 Day	10	0	0

New French Division of the Circle, compared with the Old or Common System.

New Division.	Old Value.		
100 Seconds, 1 Minute of Space	0°	1′	$32\frac{2}{5}$″
100 Minutes, 1 degree	0	54	0
100 Degrees, 1 Quadrant	90	0	0
4 Quadrants, or 400 Degrees, 1 Circle	360	0	0

Reversed.

Old Division.	New Value.		
60 Tierces, 1 Second	0°	0′	$3\frac{7}{81}$″
60 Seconds, 1 Minute of Space	0	1	$85\frac{5}{27}$
60 Minutes, 1 Degree	1°	11′	$11\frac{1}{9}$″
90 Degrees, 1 Quadrant	100	0	0
4 Quadrants, or 360 Degrees, 1 Circle	400	0	0

WEIGHTS.

Poids de Marc. English Troy Weight.

	livs	ozs.	gros.	grs.	lbs.	ozs.	drs.	grs.
Bar, or cubic metre of water	2042	14	0	14	2681	3	6	2
Myriagramme	20	6	6	63·5	26	9	15	1·46
Kilogramme	2	0	5	35·15	2	8	3	12·146
Hectogramme		3	2	10·715		3	4	8·414
Decagramme			2	44·2715			6	10·441
Gramme				18·82715				15·4441
Decigramme				1·882715				1·54441
Centigramme				·1882715				·154441

OLD WEIGHTS AND MEASURES.

Long Measure.

The toise, or fathom, of France, is equal to 6 feet French; the foot, to 12 inches French, and the inch to 12 lines, each subdivided into 12 points.—76 French feet are nearly equal to 81 English feet; or, more accurately, 40,000 French feet, inches, or lines, are equal to 42·638 English feet, inches, or lines.

Thus, 1 French foot is equal to 1.06597 English feet, or to 12·78934 English inches; and, hence, 1 English foot is equal to 11·26 French inches. The Paris aune, or ell, is equal to 46·8947 English inches, or 44 French inches, or, according to Vega, 43·9.

In the old French road measure, the lieue, or league, is two French miles, and each mile 1000 toises; hence, the French league is equal to two English miles, three furlongs, and fifteen poles.

The French league, however, in different parts of France, has been applied to various distances. The marine league—(20 to a degree)—is equal to 2853 toises, or 6081 English yards; and the astronomical league—(25 to a degree)—is equal to $2282\frac{2}{7}$ French toises, or 1865 English yards.

Superficial or Square Measure.

The arpent, or acre of land, contains, in general, 100 square perches; but the perch, which determines the measure of the acre, varies in different provinces;

the arpent of woodland, however, is every where the same, the perch being 22 feet long; and this arpent contains 48400 French square feet, or 6018 English square yards; or, one acre and one perch.

The arpent for cultivated land in the vicinity of Paris contains 900 square toises, or 4088 English yards; so 43 such arpents are equal to 38 English acres, nearly.

Corn Measure.

The corn measure was the muid equal to 12 setiers, 48 mines, or 144 bushels.

Wine Measure.

The wine measure was the muid of 36 setiers, 144 quarts, or 288 pints.

WEIGHTS.

The old French weight for gold and silver, called Poids de Marc, makes the pound, or livre, contain 2 marcs, or 16 onces, or 128 gros, or 328 deniers, or 9216 grains. The mark is equal to 3780 grains troy.

The Poids de Marc was also used in commercial transactions, and the quintal of 100 livres is equal to 108 pounds avoirdupois, very nearly.

There was no fixed standard, however, for either the weights or measures, and they varied considerably in the different provinces of the kingdom.

GERMAN MEASURE.

The Rhinland rood is the measure commonly used in Germany. It is also used in Holland, and most of the northern states, for all military purposes. It is generally divided into 12 feet, equal to 12·396 feet English; but sometimes into decimal feet, and the pace is made equal to 2 decimal feet, or two-tenths of a rood, equal to 2·4792 English feet.

The German mile—(15 to a degree)—is equal to 8116 English yards.

The scales to French and German military maps and plans are generally given in leagues, miles, toises (equal to 2·1313 English yards), or Rhinland roods. But the "*mean*" and "*common*" German miles seem to be of no determinate length. According to the table given in Tielke's Field Engineer, they vary from 19020 to 28530 Paris feet. And we sometimes find a scale denominated "a mile, or two hours walk on the road."

The Brabant league of 2800 toises, nearly, is equal to 6070 English yards; and the Italian mile of 60 to a degree, is equal to 2029 English yards.

WHEELS.

Weight and Diameter of Wheels for Field and Transporting Carriages.

I. FIELD CARRIAGES.

	Diameter.	Weight.
The 12-pounder gun, limber, and waggon, 9, and heavy 6-pounder, $5\frac{1}{2}$ inch, and 24-pounder howitzers. Take the heavy 6-pounder wheels	5 feet. —	4 cwt. 0 qrs. 26 lb.
The 9, and heavy 6-pounder limbers; light 6 and heavy 3-pounder guns and limbers; $5\frac{1}{2}$-inch, and 24-pounder howitzer limbers; 12-pounder howitzer and limber; and store and forge waggon. Take the light 6-pounder wheels	5 feet. —	3 cwt. 2 qrs. 1 lb.
The light 3-pounder and limber, and $4\frac{2}{5}$-inch howitzer and limber ..	4 ft. 4 in.—	2 cwt. 0 qrs. 15 lb.
The mountain-service guns, howitzers, and their limbers, have all the same class of wheels	3 feet. —	0 cwt. 3 qrs. 19 lb.

The ammunition and all other waggons and carriages have the same class of wheels as the limbers of their respective guns and howitzers, &c.

II. TRAVELLING AND TRANSPORTING CARRIAGES.

		Diameter.	*Weight.*
24-pounder gun and 10-inch howitzer..........		5 feet. —	8 cwt. 1 qr. 10 lb.
18-pounder gun and 8-inch howitzer.........		5 feet. —	6 cwt. 0 qr. 13 lb.
Limbers for the above....		5 ft. 10 in.—	3 cwt. 2 qrs. 10 lb.
Platform carriage	Fore ..	4 feet. —	4 cwt. 2 qrs. 3 lb.
	Hind ..	5 do. —	5 do. 2 do. 7 do.
Devil carriage		7 feet.—	11 cwt. 0 qrs. 24 lb.
Sling cart....................		5 ft. 6 in.—	8 cwt. 1 qr. 3 lb.
Flanders waggon	Fore....	4 ft. 2 in.—	2 cwt. 3 qrs. 10 lb.
	Hind....	5 do —.	3 do. 2 do. 1 do.
Hand cart....................		4 ft. 4 in.—	2 cwt. 0 qrs. 16 lb.
Pontoon carriage	Fore ..	4 ft. 2 in.—	2 cwt. 3 qrs. 20 lb.
	Hind..	5do. —	—3 do. 2 do. 1 do.

WINDAGE.

The windage of a gun, mortar, or howitzer, is the difference betwen the diameter of the bore, and the diameter of the shot or shell. See each nature of ORDNANCE, and the TABLES of SHOT and SHELLS.

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